JOURNAL

OF

THE FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

APRIL, 1866.

CIVIL ENGINEERING.

For the Journal of the Franklin Institute.

Williamsport Suspension Bridge. By ALFRED P. BOLLER, C. E.

This bridge crosses the Susquehanna River at the foot of Market Street in the above city, and at a point where the river is nearly 1000 feet wide. It was thrown open for travel during the beginning of last December, replacing the former wooden bridge which was entirely swept away by the great flood of the previous March. The whole bridge cost less than $40,000, and its construction occupied about four months. The cables supporting the structure festoon the river, as it were, in five spans, each 200 feet in length, the intermediate towers resting upon the masonry of the former piers. The general plan of bridge is known as the "Murphy Military Suspension Bridge," embodying some marked improvements and advantages which will appear further on.

The Cables, having a common versed sine of 20 feet, consist of five wire ropes for each side, of an inch and a quarter diameter, and are continuous from anchorage to anchorage. They were hauled over from one side of the river to the other by means of a windlass, and raised to their positions on the towers by ordinary block and tackle. The whole ten were stretched over the river and adjusted to place in little less than a week's time. The ends of the cables are secured in forged wrought iron thimbles, the wires being frayed out by means of tightly driven sprags, the interstices remaining being filled with lead poured in, and well hammered. The thimbles are connected with the turn-buckles, which are 18 inches long, by means of forged inch and three quarter bolts, with eyes on one end, and swivel-heads at the

other. The turn-buckles screw upon 2 inch rods, which pass entirely through the masonry.

The Anchor Masonry is, below the line of cables and above the foundation proper, a trapezium in form, 15 feet long in the line of slope, the front face being 8 feet 3 inches high, and the back 2 feet 8 inches. Upon this slope the anchor irons, consisting of five 2 inch rods, were laid, and solid masonry 3 feet high built upon them. The uniform width of the anchorage is 8 feet. The whole masonry is built of heavy flagging stones, 6 inches thick and upwards, and is thoroughly grouted from top to bottom. Each anchoring mass contains thirty-six perches of masonry. The pressure is distributed over the masonry by means of four vertical 7 inch Phœnix beams, against which and at their centre two parallel and horizontal 9 inch beams bear, separated enough to let the ends of the 2 inch rods pass between, and cast iron washers, for the nut to be screwed up against, complete the fastening.

The Towers, 27 feet high, supporting the cables, are in the form of a frustrum of a pyramid, battering at the rate of one inch to the foot. They are built of white pine 12×12 posts, mortised at their base into sills 12×14 resting upon the tops of the piers and abutments, which sills are connected at proper intervals by ties mortised into them. The hollow spaces between the sills and ties are filled in with cement masonry. These sills are continuous, *i. e.* each pair of towers is framed into the same set of sills. The legs of the towers are stiffened by having ties mortised into them and pinned with oak pins. The caps are mortised into the tops of the posts, the shoulders of the mortise being made square with them. Resting upon these caps are the saddles, also of white pine, in three pieces; the centre one of which (16 inches deep) is bolted into each cap by one inch bolts. Each pair of towers are united together at the top by means of a 10×12 tie beam, bolted to the under side of the caps by means of the same bolts that secure the centre saddle pieces. An inch and a half bolt passes through each pair of caps for attaching the truss rods to.

The Roadway is 18 feet wide in the clear, and is attached to the cables by means of white pine posts, 7 inches square, hung together in pairs, with an inch space between them for the truss rods to pass through. These suspenders are so arranged as to divide each span into ten panels, all of which are 20 feet from centre to centre. These suspenders have a slightly greater batter than the legs of the towers, so as to slope towards the chord line of the cables when freely suspended. The cables are spread in passing over the towers, but cluster at the suspension posts, passing between them, and bear against oak saddles sunk into daps in the posts, and an inch bolt passing through both posts and saddles completes the attachment. Nine inches from their lower ends, the posts are clasped by two floor beams, 6×14 each, bolted to them, and running far enough past the posts to support foot-walks on either side. These floor-beams support the stringers, which are arranged as on Plate II.

The outside stringers are packed chords, bolted to the floor-beams, and are packed in two pieces breaking joint, each piece being 5×12

inches scantling. There is one joint for each panel, which joint is always over a floor-beam. The three inch plank that composes the flooring, is laid upon these stringers and spiked to them. *The sway or lateral bracing* is formed of 1⅛ inch rods in four pieces to each panel, starting from the upper series of bolts that fasten the floor-beams and the posts together, to which they are attached by means of an eye, and through which the above described bolts pass. At the point where they would intersect they are cut off, passing into a ring of half-inch flat iron, against which the ends are screwed up and adjusted. *The truss rods* are introduced as shown upon the Plate, passing between the pairs of suspension posts, and are all of one inch round iron. For three panels each way from the towers, the tops and bottoms of the suspension posts are connected directly with the bases and tops of towers. The rods of the last panels (those that incline downwards) are secured to the bottoms of towers on their opposite sides; in other words, they pass through the nearest legs of the towers, and are screwed up against the legs on the further side. They thus act as an additional tie and stiffener for the bases of the towers. The ends of the truss rods are screwed up against oak blocks, bearing against the floor-beams and the feet of the suspension posts. In order to allow for the stretching of the cables, a camber of 12 inches for each span was framed into the bridge, and adds very much to the general appearance. It is intended eventually to put the foot-walk on, to pass through the towers and provided for in construction in the elongation of the floor-beams. The railing will be a substantial Howe truss 4 feet high. At present the bridge is subjected to a heavy amount of traffic, such as stone, lumber, cattle, &c., and it gives evidence to a surprising degree of stiffness due entirely to the peculiar system of trussing, in making the verticals act by thrust, and the diagonals by tension. This general arrangement for suspension bridges was first practised by John Murphy, Esq., C.E., over the Gauley, in West Virginia, and also at Franklin, Pennsylvania. But he used his diagonals to truss each panel separately, instead of trussing panels by attaching the diagonals to fixed points, as is the case in the above-described bridge, where the diagonals are secured to the *towers* for *six* panels out of ten in each span. *Without* the aid of the trussed railing, the effect of a heavy team passing over the bridge can hardly be felt until it strikes the span that we may be standing on, further than the slight tremor inseparable from all bridge superstructure, especially those of the suspension class. Without considerable modifications, the above construction for suspension bridges is inapplicable to spans much above 200 feet.

For the Journal of the Franklin Institute.

The Bourdon Pressure Gauge. By JOHN D. VAN BUREN, JR., U.S.N.

MR. EDITOR: I observe in the *Journal* for this month a very ingenious and plausible attempt to prove me in error as regards a note appended to my article on the Bourdon Pressure Gauge, in which I

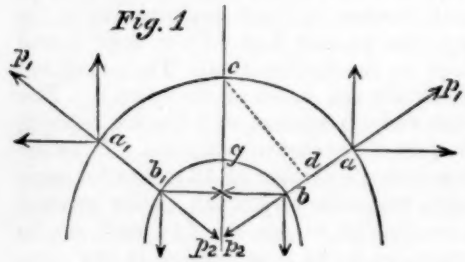
attempt to show that the principle involved in the straightening of the tube under an increased pressure does *not* depend upon the fact that the outer is greater than the inner circumference of the bend of the tube. This attempt I now proceed to prove has failed.

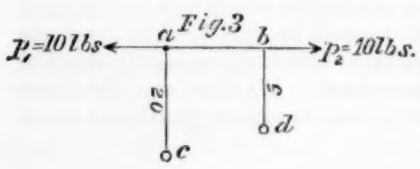
The writer makes his grand *faux pas* when he assumes as established the following two *remarkable* points:

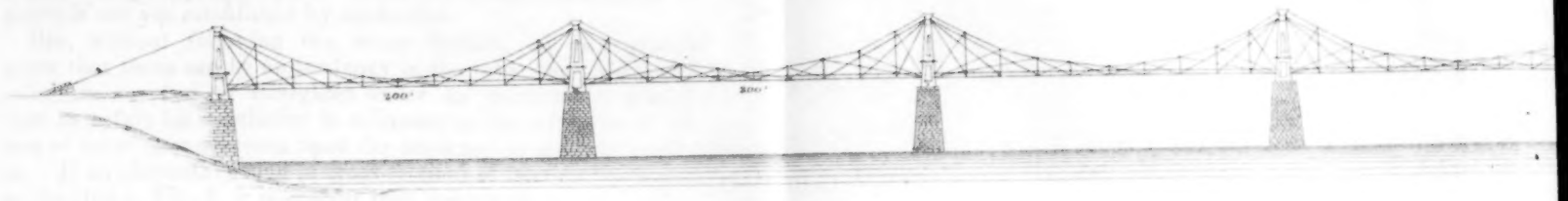
1. That in the same system of forces, when estimating their effects upon the same body, we are at liberty to take a different centre of reference for each force.

2 That the *components* of two forces will produce different effects from those of the *original* forces.

Let us refer to the figure, Fig. 1. Here we have a bent tube of circular cross-section of *invariable* size or diameter, and we may therefore assume that the points *a* and *b* are *rigidly* connected by the line *a b*. Now, he proceeds to resolve the forces p_1 and p_2 into components—an entirely unnecessary operation, tending to confusion, referring the components of p_1 to the center *c*, and the components of p_2 to the centre *g*, which, by first principles of mechanics, he has no right to do, since the forces are of the same system acting upon points of the same *rigid* body, viz: the line *a b*. If the line *a b* (or, which is the same thing, the points *a* and *b* connected by this rigid line *a b*) swerve from its original position under the effect of the forces p_1 and p_2, it must do so around a *single point* or centre, kept as it is in one plane; for there are but two possible motions, *one* of rotation and *one* of translation, and these must be estimated from a *single* point of reference, when considering the *resultant* effect of all the forces. Thus, Fig. 3, let us suppose *a b* to be a rigid line connecting the two arms *a c* and *b d*, which are pivoted respectively at the points *c* and *d*, *a c* being 20 feet in length and *b d* 5 feet in length; and that a force $p_1 = 10$ lbs. acts at *a* in the line *a b* and a force $p_2 = 10$ lbs. acts at *b* opposite to p_1. Now, no one will pretend to say that p_1 will preponderate over p_2, simply because the *moment* of p_1 is greater than that of p_2, *when estimated after the above peculiar method*—from a distinct centre? or, making $p_1 = 5$ lbs., that p_2 will *not* preponderate? But the line *a b*, Fig. 3, is under precisely the same circumstances as the line *a b*, Fig. 1; for the line is rigid, and the section *a b*, being a *circular* one, is that of equilibrium, making the elementary forces







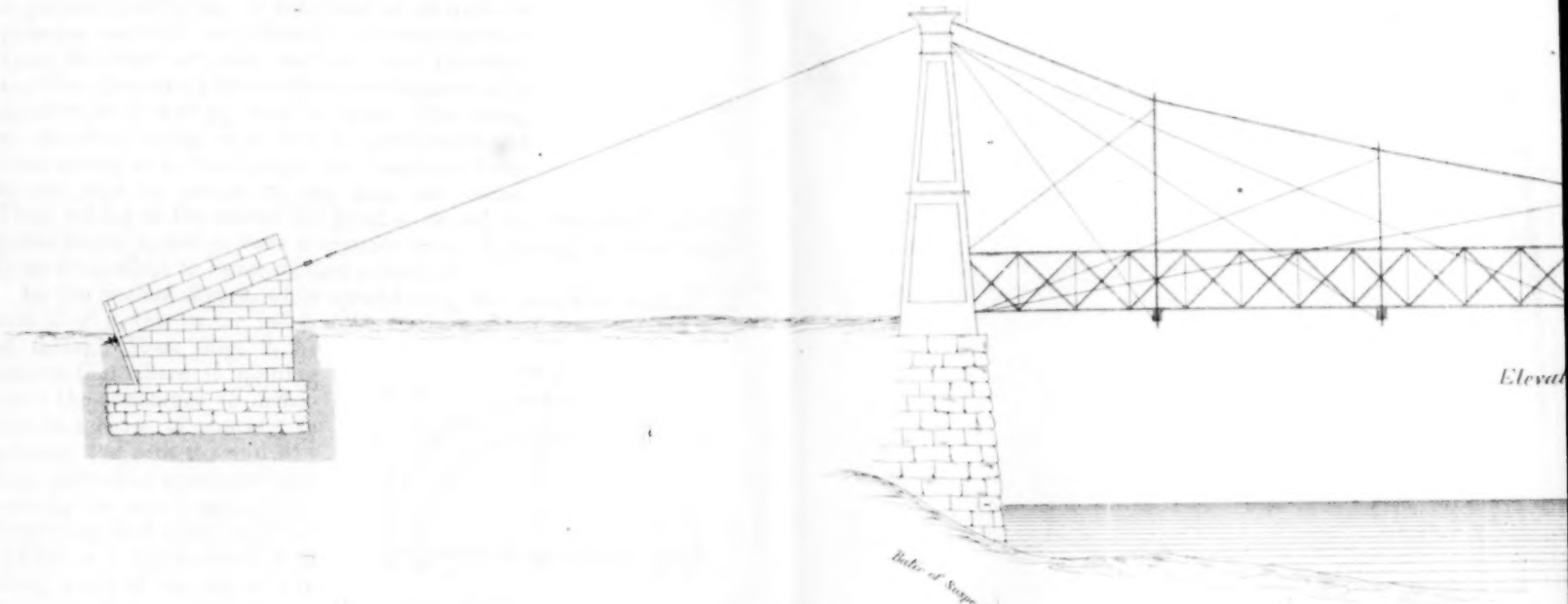


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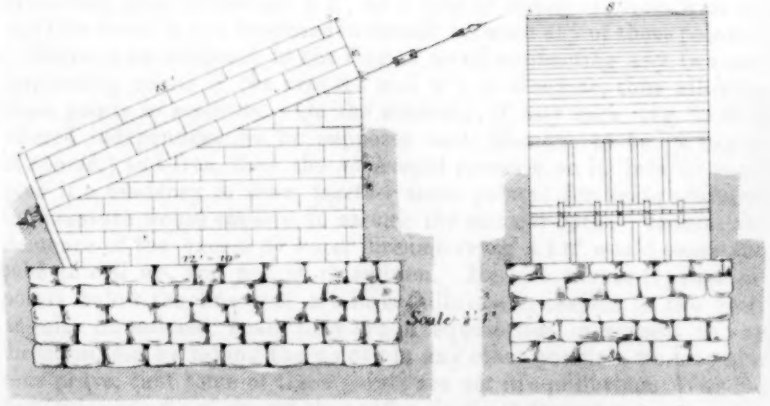
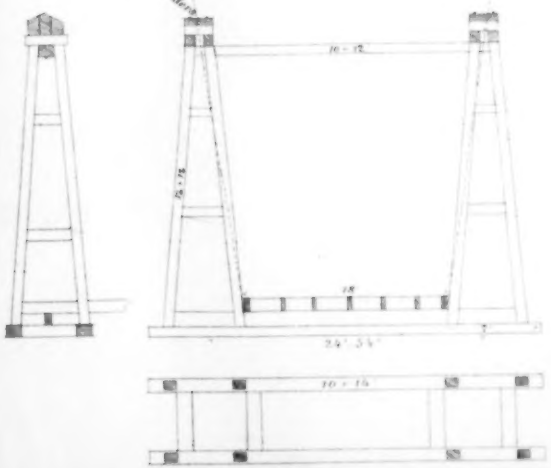
Plate of Suspenders



Side View of Anchorage

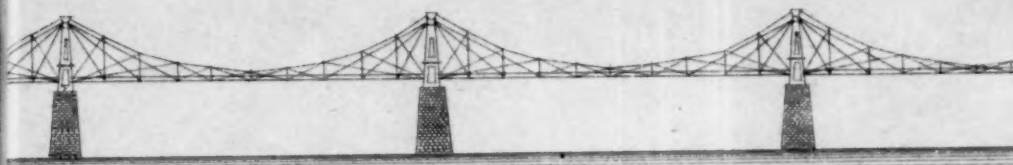
Rear View of Anchorage



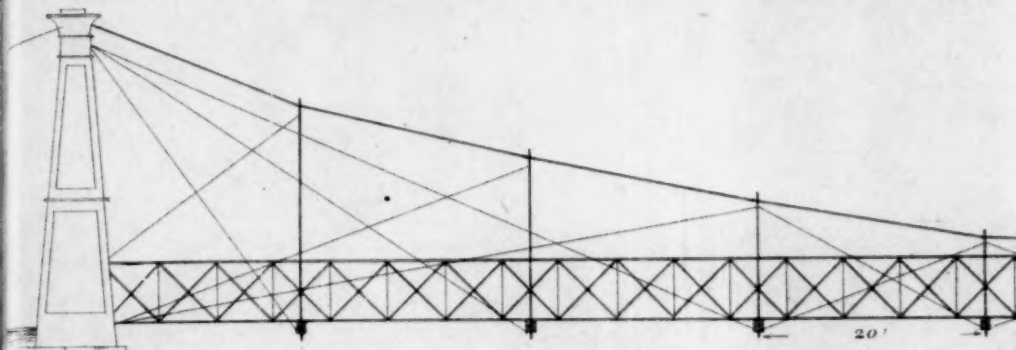
Detail of Towers

WH

Stickney and Montgomery } Cont

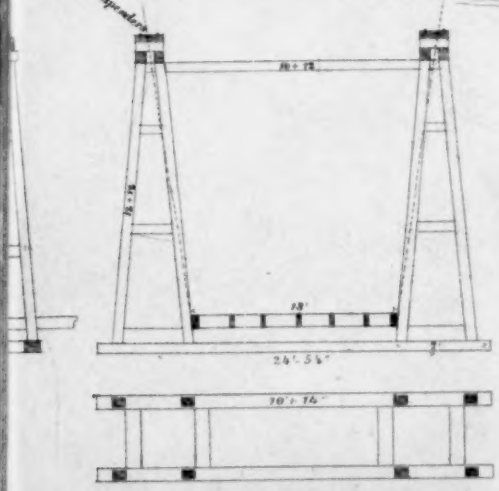


Scale 100' to 1"



Elevation of Half Span

Batter of Suspenders



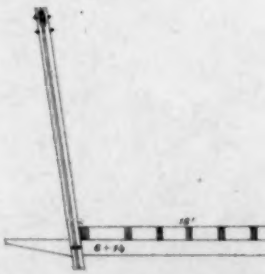
Detail of Towers

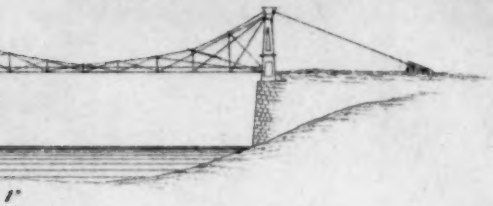
WILLIAMSPORT SUSPENS

18

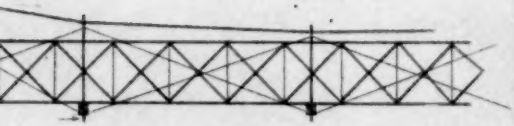
Shisley and Mongomery } Cont.rs

Scale 16' to 1"





1"



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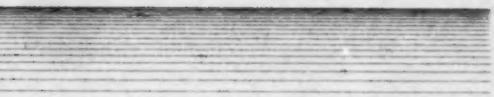
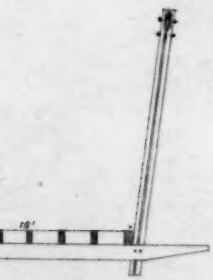


USPENSION BRIDGE

1865.

le 16' to 1".

Alf. P. Boller
Engineer.

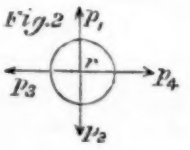


Jas. McGuigan, lith. Phila.

diametrically opposite *equal.* Such an absurd conclusion as the above is not yet established by mechanics.

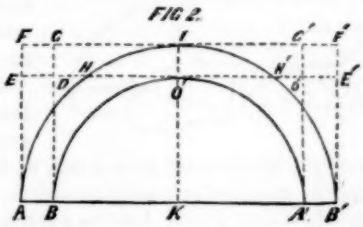
But, without following the writer further, we now proceed to prove that there can be no tendency in the tube with *invariable circular cross-section* to straighten under an increased pressure; and thus to refute his conclusion in reference to the influence of the excess of outer circumference upon the tendency in the tube to straighten. If an elementary ring (a cross-section) of the tube be considered, as the ring *r*, Fig. 2, it is evident that, having the circular form, it is in perfect equilibrium in reference to an uniform pressure exerted centrifugally or centripetally upon its inner or outer surface; and therefore any two elementary forces which are diametrically opposite, as p_1 and p_2, must be *equal.* This being so, the force acting at *a*, Fig. 1, equilibrates the force acting at *b;* and hence the *resultant* force is *zero*, and no motion of any kind can ensue. Thus, taking as the centre the point *c*, we see that the equal and opposite forces p_1 and p_2 have a common arm *c d*, leaving no unbalanced force or moment to cause motion around it.

Fig. 2



In his second figure, while considering the meridian arcs A I B′ and A′ O′ B, the writer loses sight entirely of all *intermediate* arcs of metal. Thus, Fig. 2, he asserts that there is nothing (save the resistance to *deflection* as a beam, of course,) to prevent the arcs H I and H′ I from spreading apart and thus causing the tube to straighten, forgetting that every point of the arc H I is connected with every point of the arc H′ I in precisely the same manner as every point of the arc A H is connected with every point of the arc B O′, *by a ring of metal*—as from H to H′, and this metal is not supposed to stretch between any of these points.

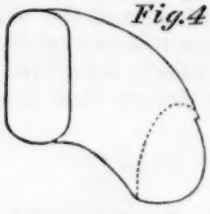
FIG 2.



There is no tendency in the ring of metal connecting any two corresponding points of the arcs H I and H′ I to elongate, thus allowing these points to *separate.* On the contrary, if any such ring be considered independent (as he supposes each filament to be, wrongly, of course,) and free, then the *horizontal* pressure on its interior must give it a tendency *to draw together* these points; for being *elliptical* the pressure would cause it to assume the circular form. Hence, the influence of the excess of outer circumference H I H′ would cause the tube to *coil up*, and not to straighten. He also proves (?) that all points below the line H H′ are in equilibrium in respect to *two* rectangular directions; *hence* they are in equilibrium in respect to any direction, *but* by taking the point I in any other position, we may also *thus* prove, that some of these points are *not* in equilibrium. Why the particular arc H I H′ should thus suffer does not appear.

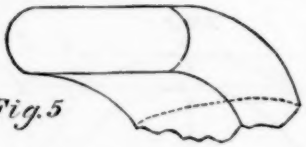
But, again :* With the same *invariable circular cross-section the capacity of the tube cannot be increased by bending the tube; for the present normal capacity is its maximum.* The capacity of the tube is found by the centro-baric theorem, by multiplying the *central* arc, Fig. 1, by the area of the cross-section, *and in no form could we place this metal, preserving its circular section invariable as well as its surface,* so as *to increase its capacity.* In fact, by bending the tube the capacity must be diminished, since the *circular section* will be destroyed. Now, the steam will force itself into the greatest possible space, thus preventing any change of shape in the tube tending to diminish its volume. Thus we prove that the tube of *invariable circular cross-section* will *not* tend to straighten under an increased pressure. If, however, the circular section be enlarged by the *stretching* of the metal, *then* our theory shows there will be a tendency to straighten under an increased pressure.

Fig. 4



Finally, it is shown, experimentally, that the tube of cross-section represented by Fig. 4 will tend to *coil up* under an increased pressure, and that the tube of cross-section represented in Fig. 5 will tend to *straighten* under the same circumstances, corroborating the theory advanced by me, which predicts these results.

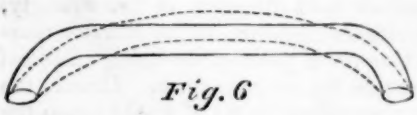
Fig. 5



In practice we often meet with very large and very long steam pipes of copper, with circular cross-sections, having a short bend at one end or both, Fig. 6; but these pipes never tend to assume any such position, as is shown by the dotted lines in Fig. 6, which would be the case if the short bends had any tendency to straighten. The rigidity being small could not prevent such action if it were exerted. So the small pipes of the hydrostatic press are never straightened under enormous pressure, unless their cross-section be other than a circle.

In my paper I concluded that the tube could not move until the unbalanced and concerting forces of extension and compression are excited in the metal of the tube by a change of section. These are the forces which directly act to move the tube. The explanation given in my paper is not only the "good and sufficient reason," but I think the *only* true explanation of the action of this gauge.

Fig. 6



P. S.—Since the above was written, a friend,—a Chief Engineer in

* In considering the effect of excess of outer circumference, the tube should be considered perfectly *flexible* and *inelastic*, and therefore liable to *wrinkle* if deflected. The tube of maximum capacity *consistent with equilibrium* is meant.

the Navy,—has made an experiment to illustrate the above principles. The apparatus used consisted of two rubber tubes of equal lengths, with *circular sections* curving from a common rubber bulb between them. When subjected to the hydrostatic pressure produced by filling the bulb with water, and placing weights upon it, the tubes showed no perceptible tendency to straighten; although, according to my paper, if the cross-section had enlarged by the stretching of the material, *then* a slight straightening of the tubes should have resulted. This crucial test is conclusive of the correctness of the theory I have mathematically demonstrated.

For the Journal of the Franklin Institute.

On the Steam and Exhaust Ports of Steam Cylinders—The practicability of a material reduction in their dimensions suggested. By D. M. Greene, U. S. Naval Engineers.

The rules employed by designers of steam machinery in determining the areas of steam ports and passages, seem to be generally, if not always, entirely arbitrary; indeed, the "*rule of thumb*" appears to be not only the principal one used, but to find advocates in quarters and under circumstances where they would be least expected. The ever-varying conditions of steam pressure and velocity of piston appear to be ignored, and the unwarrantable assumption made, that the relation between the areas of the ports and passages, and of the piston once determined, for an engine working under a given steam pressure, and with a given velocity of piston, furnishes a reliable precedent in designing all engines whatever may be the conditions under which they are to perform their functions.

In engines of great power, having large cylinders, and using steam of more than ordinary high pressure, great difficulty has been experienced in securing a proper action of the valves. This has been owing to the excessive weight of the valve, together with the enormous steam pressure upon its back, causing a rapid destruction of its face by friction. Much ingenuity has been expended in providing remedies for this evil, and as the results we have, among other contrivances, the "vacuum ring," the "Wadell plate," and the steel roller, all of which possess merit; but which, while affording partial relief, are objectionable on account of the difficulty attending their proper fitting up and adjustment, and especially on account of their liability to derangement after having been once adjusted.

It seems strange that, while so much has been done to mitigate the *effect* of the evil of large and heavy valves, nothing appears to have been done to reduce the *evil itself* to its minimum practicable proportions. Why has not some one suggested that the ports, and consequently the valves, as now proportioned, may be twice or even three times as large as necessity requires?

The writer, in constructing a formula for his own use in determining the proper areas of opening for steam ports, has had his attention forcibly directed to this matter by the result obtained; and, feeling

that the subject is one of profound interest to the profession, will now indicate the course pursued by him in its examination.

Steam passes from the steam chest to the cylinder by virtue of an excess of pressure in the former over that in the latter. What this excess of pressure is, however, in practice, we are without reliable information; no experiments, to our knowledge, having been made with a view to determine it.

Indeed, such information is not essential; as we may assume any admissible excess of pressure, and base our determination upon such assumption. We will, therefore, assume 0·3 of a pound as an excess which is not only entirely admissible, but even considerably less than may be allowed in practice. This assumption being made, the velocity with which the steam will enter the cylinder through the port will be that due to the height of a column of the entering steam, the weight of which is equal to the assumed excess of pressure; in other words, the velocity of the current will be that which a body would acquire, in falling freely through the height of a column of the entering steam, having a base of one square inch, and weighing 0·3 of a pound. The volume of steam admitted through the port will depend upon the area of the port and upon the velocity of the current; while the volume of steam required to be admitted in the same time, will depend upon the area of the piston and its velocity.

In order to express these conditions in the form of an equation, let

D = diameter of cylinder in inches.
A = area of piston in inches.
V = velocity of piston in feet per second.
a = area of steam port in square inches.
Ka = effective steam port in square inches.
v = velocity of entering steam in feet per second.
S = stroke of piston in feet.
p = pressure of steam in steam chest above zero.
δ = difference of pressure in steam chest and cylinder.
h = height due to V.
C = specific volume of steam of pressure p.
r = number of revolutions per minute.

Then will

$$v = \sqrt{2gh},$$

and

$$\text{K}\,a\,v = \text{K}\,a\sqrt{2gh};$$

which represents the volume of steam admitted to the cylinder per second. But this volume is also represented by A V; hence

$$\text{K}\,a\sqrt{2gh} = \text{A}\,\text{V};$$

whence

$$a = \frac{\text{A}\,\text{V}}{\text{K}\sqrt{2gh}}, \quad . \quad . \quad . \quad (1.)$$

Now, $A = \cdot 7854\ D^2$, and $V = \frac{2\,r\,s}{60} = \frac{r\,s}{30}$.

Substituting in (1) we get

$$a = \frac{\cdot 7854\ D^2\ r\ s}{30\ K\ \sqrt{2\,g\,h}}, \quad . \quad . \quad . \quad (2.)$$

To determine h, in terms of c and δ, we have but to remember that a column of steam of the pressure p, having a base of one square foot, and a height of c feet, weighs 62·5 pounds; while if the base be but one square inch, the weight of the column will be $\frac{62 \cdot 5}{144}$ pounds; then to find how much of this column will be required to weigh δ pounds, we have the proportion,

$$\frac{62 \cdot 5}{144} : \delta :: c : h;$$

whence

$$h = \frac{144\ \delta\ c}{62 \cdot 5}$$

$$= 2 \cdot 304\ \delta\ c.$$

Substituting now this last value of h in (2) we get

$$a = \frac{\cdot 7854\ D^2\ r\ s}{30\ K\ \sqrt{2\,g \times 2 \cdot 304\ \delta\ c}}$$

$$= \frac{\cdot 7854}{30\ \sqrt{2 \times 32 \cdot 16 \times 2 \cdot 304}} \times \frac{D^2\ r\ s}{K\ \sqrt{\delta\ c}}$$

$$= \frac{\cdot 7854}{30 \times 12 \cdot 17} \times \frac{D^2\ r\ s}{K\ \sqrt{\delta\ c}} = \cdot 00216\ \frac{D^2\ r\ s}{K\ \sqrt{\delta\ c}}, \quad . \quad (3.)$$

If we make $\delta = 0 \cdot 3$ of a pound, as already indicated, (3) becomes

$$a = \frac{\cdot 00216}{\sqrt{0 \cdot 3}} \times \frac{D^2\ r\ s}{K\ \sqrt{c}} = \cdot 004\ \frac{D^2\ r\ s}{K\ \sqrt{c}}, \quad . \quad . \quad . \quad (4.)$$

For long and narrow rectangular ports, K may be taken as ·8, and (4) will become

$$a = \cdot 005\ \frac{D^2\ r\ s}{\sqrt{c}}, \quad . \quad . \quad . \quad (5.)$$

For circular ports, as when the puppet valve is employed, K may be taken as ·62, in which case (4) becomes

$$a = \cdot 00645\ \frac{D^2\ r\ s}{\sqrt{c}}, \quad . \quad . \quad . \quad (6.)$$

The following table furnishes a few values of c. Where the values of p differ from those given, recourse may be had to a more complete

table; or, in its absence, c may be determined with sufficient accuracy by the "Law of Mariotte."

p (In pounds above zero).	c	p (In pounds above zero).	c
15	1669	105	282
30	883	120	251
45	610	135	224
60	470	150	205
75	383	165	187
90	325	180	174

To exemplify the application of our results, let $D = 100''$, $r = 40$, $s = 4'$, and $p = 60$ pounds. Then will (5)

$$a = \cdot 005 \times \frac{100^2 \times 40 \times 4}{\sqrt{470}} = 368{\cdot}75 \text{ square inches.}$$

Thus we see that, the ports being rectangular, the aggregate opening at each end of the cylinder should be 368·75 square inches. If the ports be double, and their lengths be 82 inches, their widths will evidently be $\frac{368{\cdot}75}{2 \times 82} = 2{\cdot}25$ inches.

Again, let $D = 60''$, $r = 65$, $s = 2\frac{1}{2}'$, and $p = 45$. Then will (5)

$$a = \cdot 005 \times \frac{60^2 \times 65 \times 2\frac{1}{2}}{\sqrt{610}} = 102{\cdot}6 \text{ square inches.}$$

The data for these examples are taken from the "one hundred inch" and the "sixty inch" engines, now being constructed for the Navy Department; and the results are practically identical with the areas given to the ports of the cylinders of those engines. These areas were determined by the usual method, *i. e.* by making them a certain function of the areas of the pistons; whereas, it is apparent, from the formula, as well as suggested by common sense, that they should also have been made functions of the number of revolutions and the strokes of the pistons.

To prevent any misapprehension in regard to the apparent coincidence of the results given by the two methods, it is proper to remark that, had the number of revolutions proposed in the first example been 50, instead of 40, the resulting area of the port given by the formula would have been 25 per cent. greater; while the result given by the "rule of thumb" would have been the same.

It may be said that a larger cylinder would have been required, but even then the increased speed of piston would have rendered the result unreliable.

Now, to ascertain whether or not it be practicable to reduce the areas of these ports, let us solve (3) with respect to δ. We get

$$\delta = \frac{\cdot 00216^2 \, D^4 \, r^2 \, s^2}{a^2 \, K^2 \, C};$$

whence it appears that, other things being equal,

$$\delta \propto \frac{1}{a^2}.$$

Let now a_1 and δ_1 represent another area of port, and the corresponding value of δ, respectively; then we have from the relation just noticed,

$$\delta : \delta_1 :: \frac{1}{a^2} : \frac{1}{a_1^2};$$

whence

$$\delta_1 = \delta \cdot \frac{a^2}{a_1^2}.$$

If $a_1 = \frac{1}{2}\, a$, this becomes

$$\delta_1 = \delta \cdot \frac{a^2}{\frac{1}{4}\, a^2} = 4\, \delta;$$

but we have constructed our formula, and applied it upon the hypothesis that $\delta = 0{\cdot}3$;

$$\therefore\ \delta_1 = 4 \times 0{\cdot}3 = 1{\cdot}2 \text{ pounds.}$$

Thus it appears that, in order to realize the advantages of a port only one-half as large as that now employed, we have only to increase the boiler pressure 0·9 of a pound. If a_1 had been made $= \frac{1}{3} a$, we should have found

$$\delta_1 = 9\, \delta = 9 \times 0{\cdot}3 = 2{\cdot}7 \text{ pounds,}$$

which shows that, as the area of the port is made considerably less than one-half that which is at present employed, the excess of pressure in the steam chest over that in the cylinder soon becomes too large to be admissible.

Among the important advantages which would result from the adoption of a port one-half the present size would be: first, a saving of nearly or quite one-half in the weight of the valve, and in the steam pressure in its back; and second, a very large saving in the clearance space in the nozzles.

To best secure these advantages, the present *width* of port should be preserved, while the *length* should be reduced one-half. (5) and (6) for this case would become

$$a = {\cdot}0025 \cdot \frac{D^2\, r\, s}{\sqrt{c}} \qquad . \qquad . \qquad . \qquad (5a,)$$

for rectangular ports, and

$$a = {\cdot}0032 \cdot \frac{D^2\, r\, s}{\sqrt{c}} \qquad . \qquad . \qquad . \qquad (6a,)$$

for circular ports.

In this connexion, it may not be amiss to call attention to the (to

our mind) absurd practice of making the exhaust openings and passages twice as large as the steam passages. It will be remembered that, in the first example given, the velocity with which the steam enters the cylinder is due to an excess of pressure in the steam chest of only 0·3 of a pound; while the absolute pressure, at the end of the stroke, which forces the exhaust into the condenser is—allowing for the reduced pressure due to expansion—about 51 pounds. Now, $\frac{51}{0{\cdot}3} = 170$; or the pressure head to which the velocity of discharge is due is about 170 times as great as that to which the velocity of the steam entering the cylinder is due; and since these velocities are proportional to the square roots of their respective pressure heads, they will be to each other as $\sqrt{1} : \sqrt{170}$; or, 1 : 13. Hence, in this particular case, the velocity of egress will be 13 times as great as the velocity of ingress. With the more usual pressures of 30 to 40 pounds above zero, the velocity of egress will be about 10 times that of ingress. Even with the reduced port, in the case of the "hundred inch" cylinder, the velocities would be $\sqrt{1} : \sqrt{\frac{60}{1{\cdot}2}}$; or, 1 : 7.

Why, then, make the exhaust opening larger than the steam opening?

The suggestions contained in this paper are offered especially for the benefit of the younger members of the profession; and also in the hope that individuals having facilities may be induced, by the importance of the subject, to institute experiments with the view of ascertaining whether the advantages claimed for the reduced port may or may not be realized.

Washington, D. C., February 15, 1866.

Phillips' Patent Girder and Fire-proof Flooring.

From the London Mechanics' Magazine, December, 1865.

On Tuesday last some important experiments took place at Mr. Kirkaldy's testing works, the Grove, Southwark, with the above inventions, in the presence of a large number of practical engineers and other scientific gentlemen. Mr. Kirkaldy, who has long been known in connexion with experiments on iron and steel, has recently erected an enormous machine, possessing testing powers from ten pounds to one million pounds, which records its own progress and conclusions with the certainty and exactitude of a chronometer. He conducted the experiments in person, assisted by Mr. Homan. The patentees of the girder, Messrs. W. and T. Phillips, of the Coal Exchange, were also present. The peculiarity of the new invention consists in the flanges being rolled solid, instead of being riveted as heretofore, whilst the web is somewhat thicker than usual. The first experiment was with a light girder 8 inches deep, with 2½ inches flanges, and 20 feet between the supports; the weight was 22 pounds per foot run, the iron being equal to ordinary Staffordshire plate. For the purpose of

understanding the comparison it may be stated that the breaking weight of a similarly sized riveted girder is about four tons, the distributed safe load being about two tons. In the experiment with the new girder the old breaking pressure of four tons was immediately applied; when withdrawn after a short time it was found that the limit of electricity had not been reached, as no permanent set was discernible. Five tons were then put to the centre of the beam, as before, which showed a permanent set in the metal, but to the smallest appreciable extent. The pressure was then increased for breakage, and at about seven tons the supports gave way, and the beam turned over from the machine. Examination was critically made to discover fracture, but, although a considerable vertical set had taken place, no separation of the metal was observable. The next experiment was a girder having the lower flange $2\frac{1}{2}$ inches by $\frac{3}{8}$ inch, the top flange being 8 inches by $\frac{3}{8}$ inch, whilst the depth was about 16 inches; this girder was riveted in the middle. The breaking weight of a similar girder with riveted flanges is ten tons, but the new solid rolled flange refused to move under that pressure, or even at twelve tons. The strain went on to sixteen tons, when it began to set only, and at eighteen tons it jumped out of the machine like the previous ones, through the giving way of the supports. A close inspection showed that beyond the slight setting this girder has suffered no injury whatever; and, as it so far exceeded Mr. Kirkaldy's expectations of its resisting powers, it was agreed to postpone the remaining experiments for a month, in order that the testing machine should be expressly prepared for this unlooked-for new girder.

Advantage was then taken of the opportunity to inspect the Messrs. Phillips' new fire-proof flooring. It consists of rolled iron joists 2 feet apart, with iron laths resting on the bottom flange. On these laths concrete is laid to the depth of four or five inches, and in the concrete the dove-tailed timber joists are buried. The under side forms an effectual key for the plaster ceiling, which can be easily applied by any ordinary workman. It is believed that this floor can be laid as cheaply as any ordinary floor, and at much less cost than any fire-proof flooring now used.

For the Journal of the Franklin Institute.

"Vacuum" and the Indicator. By JOHN T. HAWKINS, First Asst. Eng. U. S. Navy.

I have on many occasions observed that there exists, and among young engineers particularly, a very material confusion of ideas upon the real condition of things within the condenser of a steam engine. Nor is it to be wondered at that this is the case under the present system of expressing the variations of pressure within a condenser in "inches of vacuum," the numbers increasing as the pressure diminishes seeming to them to represent, not the pressure therein, as it should, but certain degrees of absence of pressure,

A perfect vacuum, or total absence of pressure, is an unvarying standard, and to simplify the real relations of the condenser with the boiler, instruments now known as vacuum gauges should be changed in name and made to record upward in pounds per square inch, precisely as the steam gauge does; then the apparent mystery surrounding the idea of a vacuum would never insinuate itself into the minds of learners nor cause confusion among the better informed.

All vacuum gauges of the nature of the closed top manometer, as the scale upon them is now arranged, indicate incorrectly for every variation of the atmospheric pressure and can only be correct for one. For instance, the manometer scale is graduated upon the supposition that the atmospheric pressure is equal to 30 inches of mercury, and the lowest figure upon the scale is 30, diminishing upward. If, with a perfect vacuum in the condenser, the mercury descends to the point marked 30 at one pressure of the atmosphere it will at any other, or even if there were no atmospheric pressure at all; so it is manifestly incorrect to say that the vacuum in the condenser is equal to 30 inches of mercury, if the pressure of the atmosphere will support no more than 28 inches, or if it be sufficient to support 31 inches. But if we place 0 upon the scale in the place of this 30, and graduate it upward in divisions representing pounds and fractions of pounds pressure to the square inch in the condenser, this gauge will indicate absolutely correct whatever the variation may be of the atmospheric pressure; and, moreover, it would be impossible to misapprehend the indications.

With all vacuum gauges that are affected in their indications directly by the variations of the atmospheric pressure, such as the open syphon and the different varieties of spring gauge, we must make corrections, by means of the barometer, to be able to determine the exact pressure in a condenser; and it would be just as easy to do this if the numbers began at the perfect vacuum point and read upward as the pressure increased, as it is now with the numbers reading in the other direction, and would be much more intelligible. There can be no positive point upon the dial or scale of such a gauge to indicate a perfect vacuum, nor can there be any such point at which any given pressure in the condenser can be recorded, no matter in what particular manner the dial or scale may be divided or numbered, so that the corrections must be made for every variation of the atmospheric pressure under any circumstances; and certainly it would be much less ambiguous to have the indications read, for instance, 2 lbs. pressure in the condenser—and be sure to convey that idea to the mind—instead of 26 ins. of vacuum; for to know the pressure (which is what we really require) we must deduct this 26 from 30, and if the barometer reads 28 ins. instead of 30 ins. we must deduct 24, which the gauge would then indicate, not from 30 but from 28, while, under the same conditions, (the scale counting upward in pounds,) the scale would indicate 3 lbs. pressure, and we would have to simply reduce that indication one-half pound for every inch the barometer stood below 30.

We may trace the results of this really erroneous method of indicating pressures below that of the atmosphere to that very important

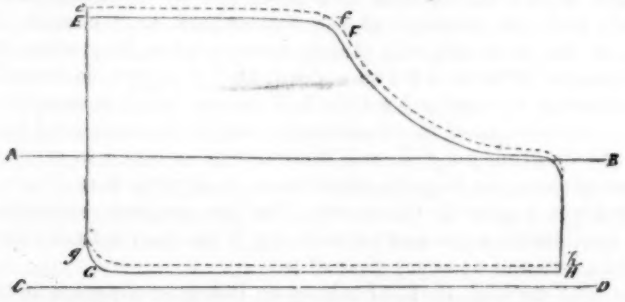
instrument, the indicator, and find that it gives rise to errors of a considerable magnitude where accuracy is required.

The indicator itself is nothing more than a pressure gauge, indicating, precisely as the open mercurial or the various spring gauges do, the difference of the atmospheric pressure and that within whatever vessel it may be attached to, varying in those indications with every variation of the pressure of the atmosphere.

It is customary, and indeed very explicit instructions are given to engineers, to take both the atmospheric and perfect vacuum lines upon a diagram; but how to take them, or rather, make them correct, is not always told, and in many cases is not really understood. Most indicators are arranged with a stop, down to which the piston may be forced, and a line traced by the pencil while so held by the hand is generally regarded as the perfect vacuum line, to which all other lines in the diagram may be referred. Now, it would appear to many at first sight that, inasmuch as the atmospheric pressure varies while a perfect vacuum does not, if a correction is necessary to be made for a variation in the atmospheric pressure, it only requires that the atmospheric line, as traced by the instrument, shall be raised or lowered accordingly as the atmospheric pressure is greater or less than 30 ins. of mercury.

It is not difficult, however, to show that the only line to which all parts of an indicator diagram may be referred, truly, is the atmospheric line taken with the pressure of the atmosphere admitted to both sides of the indicator piston, for which provision should always be made in the arrangement of an indicator or the pipes and cocks connecting it with the cylinder.

To make the truth of this statement quite clear, suppose the continuous line E F H G in the figure to represent a diagram taken from a condensing engine; A B the atmospheric line taken with the atmo-



sphere admitted to both sides of the indicator piston; C D the perfect vacuum line, taken by forcing the piston down to the stop. Let the scale of the indicator be 1 inch = 10 lbs., the atmospheric pressure = 14·7 lbs., and the total initial pressure in the cylinder = 29·7 lbs. Under these circumstances, the vertical distance between the perfect vacuum and atmospheric lines will = 1·47 inches, and that between the atmospheric line A B and the steam line E F will = 1·5 inches;

and if there be, say, 2 lbs. pressure to the square inch in the condenser, the distance between the vacuum line G H, traced by the instrument and the perfect vacuum line will = 0·2 inch.

Now, to prove that this perfect vacuum line is not correct for any other pressure of the atmosphere, let us see what the effect will be, upon the entire diagram, of a reduction of the atmospheric pressure to 13·7 lbs. First, the vacuum line traced by the instrument, instead of being found at G H, will be 0·1 inch higher, as the dotted line *g h*, because with a given pressure beneath the indicator piston the reduced pressure of the atmosphere is insufficient to depress it so far. Again, we will find the steam line, instead of E F, will be traced 0·1 inch higher also, as *e f*, because a given pressure beneath the indicator piston is sufficient to force it higher with the pressure above it diminished. The whole diagram, therefore, will be traced 0·1 inch higher, relatively to either the atmospheric line A B, or the perfect vacuum line C D.

But with the pressure of the atmosphere at 13·7 lbs., the vertical distance between the atmospheric and perfect vacuum lines should be but 1·37 inches; one of these lines is, therefore, incorrect; either A B is too high, or C D is too low. Let us see which it is.

If the line C D correctly represents the perfect vacuum, the vertical distance between it and the dotted steam line *e f* should be 2·97 inches, for that distance represents the total pressure, which has not been altered; and for the same reason the vertical distance between C D and the dotted vacuum line *g h* should be 0·2 inch. But we see that those distances will be respectively equal to 3·07 and 0·3 inches. It is clear, then, that the line C D does not correctly represent the perfect vacuum with the atmospheric pressure at 13·7 lbs.

Now, if we refer either the dotted or full line diagram to the atmospheric line A B, we find it correct for both; for the vertical distance between it and the vacuum line described by the instrument varies exactly with the pressure of the atmosphere, as it should; and the same is the case with the steam, or any other line above it; thus the distance between A B and *e f* will be 1·6 inches, as it should, and that between A B and *g h* will be 1·17 inches, which is equally correct.

If it were required to calculate the weight of steam used per stroke from the diagram *g e f h*, and the line C D be taken to represent the perfect vacuum, as is quite often done, it is plain that a very considerable error would be the result; for the diagram exhibits, under these conditions, a greater pressure by 1 lb. than actually existed in the cylinder, and at every part of it.

The true method, then, of taking an indicator diagram is to admit the pressure of the atmosphere to both sides of the indicator piston when the atmospheric line is traced, record the reading of the barometer after the entire diagram is taken, and lay off the perfect vacuum line from the atmospheric one at our leisure, and in accordance with the barometric record.

It might be urged, that having the record of the barometer at the time the diagram was taken, we can lay off the perfect vacuum line

as well from the false one, taken by depressing the indicator piston to the stop provided for the purpose, as from the atmospheric line. And so we may; but the atmospheric line does not belie its name, and no confusion of terms or ideas can result from referring the entire diagram to it, while with the false vacuum line such a result is more than probable; indeed, I have seen this exemplified on many occasions; beside, one line is sufficient, and, that being the case, we do well to take that which is always correct.

The term "vacuum," as applied to the condenser of a steam engine, is at best a grievous misnomer, and the term "partial vacuum," together with the idea it conveys, is no less than absurd. Either there is a vacuum or a pressure, and the latter invariably obtains in the condenser. No matter how great or how small that pressure may be, it is never in any correct sense a partial vacuum. As well might we say of a boiler having a pressure within it of 100 lbs. to the square inch, when referring it to, or comparing it with, another in which 101 lbs. was maintained, that there was a partial vacuum within it, as to say there is a partial vacuum in a condenser because the pressure therein was something less than that of the atmosphere outside. Or, if the barometer indicates to-day 28 inches and to-morrow 30, it could with equal propriety be said that to-day we have a partial vacuum around us.

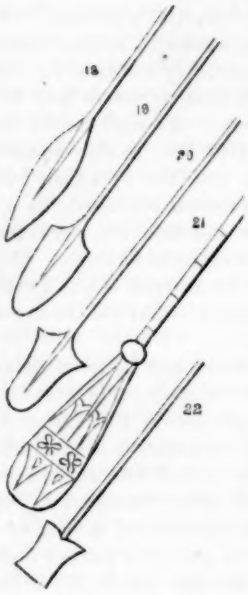
So long as the atmospheric pressure varies, there can be no positive line drawn to divide what, under the present system, is understood as a partial vacuum from a positive pressure; and herein lies the evil. The use of the term "vacuum" should only be to express a total absence of pressure, and any deviation from that condition should be regarded as something positive and capable of being measured. A vacuum can no more be measured than can a mathematical point, and it should be presented to the minds of learners in just that sense; then they would not be obliged to unlearn in their maturer years the erroneous impressions received by them during their younger days, as is certainly now the case to a great extent, so far as this subject is concerned.

I have seen so many instances of the bad effect of the misuse of these terms, authorized, and indeed rendered almost indispensable, under the present system of dividing and numbering the figures upon the dials or scales of instruments for measuring condenser pressures, that I am persuaded a radical change should be made, and that the sooner it is commenced the better. The form in which this subject is now generally presented to our view is but a relic of by-gone times, when men's minds had not yet been entirely freed from the gloom of the dark ages; when nature was supposed to possess many mysterious and unfathomable secrets, since revealed by the steadily increasing brightness of the head-light of science, as the iron horse of investigation came thundering down the track of time.

For the Journal of the Franklin Institute.

Increasing the Speed of Steamers—Form of Propelling Blades—The Oar and Paddle.

Since forwarding the article in last month's *Journal*, I have selected from the volumes of Champollion and Rosellini the annexed illustrations. In tome iv. of the former, Plate 403, are two Egyptian galleys with oars acutely tapered and pointed as in Fig. 18. This was a common form. (See tome ii., Plates 127, 128, 130.) *Oar makers* are represented at work dressing the shafts of blades, all spear-shaped, tome iv., Plate 369, and Rosellini, tome ii., Plate 43. The central longitudinal ridge is marked on all.



19 and 20. Oars in the hands of boatmen about to step on shore, Ros. tome ii., Plate 105. The blade of the latter is identical with that of the Indian paddle, in the *Journal of the Franklin Institute*, for October, 1848.

21. Specimen of ornamented rudder-oars—the common form; some are less, others more elaborately decorated by carving and painting.

22. An Assyrian oar from a Brieme in the palace of Sennacherib. Rawlinson's Herodotus i., 232: London, 1862. In Olaus Magnus' History of the Goths—Historia Olai Magni Gothi Archiepiscopi Upsalensis de Gentium Septentrionalium, . . . Basil, 1567, —the oar repeatedly occurs in the numerous wood-cuts and, except acutely pointed blades, in most of the forms already given.

The fact that in nature increased speed is not accompanied with enlarged propelling surface should have been dwelt on. The mechanical principle is not only of special interest in itself, but of the very first importance in naval engineering. Its practical value cannot be over-estimated, yet it does not appear to have been thought of, and but for its demonstration in natural organisms would not now be believed in, so contrary it is to our general practice. The more sail a ship carries the faster she moves, and to double the speed of a bird the common inference would be that its wings should be enlarged. Had this been the law some departments of creation would present very different scenes to those we behold. To convert slow into swift flyers and swimmers, propelling organs would have been three or four times heavier than now and required corresponding additions of force to work them. Such is the plan we have followed instead of the living one before us, which, to say the least, should be tried, since it is granted on all hands, that increased speed must be obtained and will be, if not by us, by those who come after us. Some leading authori-

ties for the enunciation and elucidation of new doctrines in natural, and, consequently, in practical mechanics are greatly needed.

Undeveloped agents are wanted for some arts to advance, but for propulsion we appear to possess all that engineers for ages will have as regards materials and forces, so that there is nothing to prevent us from anticipating them in high speeds if we will but make the best use of the means in our power. E.

Large Iron Railway Bridge.

From the London Mechanics' Magazine, December, 1865.

The Newhaven, Hartford, and Springfield Railroad Company are now erecting a fine bridge across the Connecticut River at Warehouse Point. When completed this will probably be the finest railroad bridge in the United States. It is built on the truss principle, and consists of seventeen spans, the longest being 177 feet, extending over the river, the carriage road, canal, and tow-path. The entire length of the structure is 1525 feet. The total weight of iron used in its construction is about 700 tons, and cost in England, where it was made, £11,231. The plans for its construction were designed by Mr. James Laurie, an American engineer, and were at first tendered to an iron firm in Philadelphia, but at that time nearly all the large iron workers in the country were engaged on government work, and it was finally determined to procure the construction of the bridge in England. The contract was awarded to William Fairbairn & Co., of Manchester, but afterwards a portion of it was assigned to the London Engineering and Ship-building Company. The bridge being built in sections and fitted together, was then taken apart and shipped to America. About 175,000 rivets are employed in fastening together the various pieces. The great difficulty encountered in putting the bridge in its place arose from the fact that the new bridge is to occupy the same position as the present wooden one, and it was desirable that the traffic of the road should not be interrupted while substituting the one for the other. A good deal of planning and study was required to effect this object, but the skill and ingenuity of Mr. Laurie have hitherto overcome all obstacles, and most of the spans are now in position, without, we believe, a single interruption to any train. The erection of the bridge was commenced about the 1st of July last, and it is expected that the entire structure will be in position and completed by the end of January next.

MECHANICS, PHYSICS, AND CHEMISTRY.

For the Journal of the Franklin Institute.

Expansion Trials with the U. S. Steamers Algonquin and Winooski.

By Isaac Newton, late of the Engineer Corps, U. S. N.

A number of indicator diagrams, taken from various steamers fitted with precisely the same valves and valve gear as that of the *Wi-*

nooski, and an examination of the cut-off of a number of the same type of engine to which an indicator has not been applied, exhibited the fact that the usual point of cut-off adopted in American marine practice is from *four* to *five*-tenths of the stroke of the piston. It may therefore be assumed that this measure of expansion, taking the usual conditions of practice into consideration, is the measure which has been found to give the best practical results. This does not prove, however, that no gain can be attained by suppressing the admission of the steam at an earlier point of the stroke; on the contrary, many well attested examples prove that a gain has been effected by shortening the cut-off. In the Cornish pumping, which is well known as one of the most economical types of steam engine, the steam is frequently cut off at from one-twelfth to one-sixth of the stroke; the performances of well-proportioned engines of this class, in good order, are too well known to require repetition here. Not only in the Cornish engine, but also in reciprocating engines, has an equal increased efficiency been the result of an extensive application of the expansive principle.

Toward the close of the year 1860, Mr. Isherwood, the present Chief of the Bureau of Steam Engineering of the Navy Department, carried on a series of expansion experiments on the U. S. paddle steamer *Michigan*, on Lake Erie. Hence the name by which these experiments have since been known, "Erie Expansion Experiments." The results of these experiments, as "discussed" by Mr. Isherwood, are of such a remarkable character, and as his subsequent practice as Engineer in Chief has been governed entirely by his opinion of these results, the profession have watched the so called economy dock trials between the *Algonquin* and *Winooski* with more than ordinary interest. It is true these trials were ostensibly started in order to prove whether or no certain stipulations in a contract had been fulfilled, but the only valuable or interesting point involved—for reasons already mentioned—was the value of the theories maintained by the Chief of the Naval Steam Bureau, with respect to the expansive principle. To make a long story short, the position taken by this gentleman was, that this principle was a delusion. In order that these experiments may be fully comprehended, the principal features and dimensions of the competing machinery will be given.

First. The *Algonquin*, the entire machinery of which vessel was designed by Mr. E. N. Dickerson, a lawyer by profession, but one who has devoted much attention to steam engineering. This vessel is fitted with an ordinary inclined engine, the cylinder of which is 48 inches in diameter by 10 feet length of stroke; the valves are of the single poppet style; the steam valves are arranged with the old "drop valve cut-off," which is easily adjustable, while the engine is in motion, to any point of the stroke.

The clearance at each end of the cylinder between the piston and valves is 7·5 cubic feet.

The steam is condensed by a surface condenser of very great external magnitude in proportion to the refrigerating surface exposed to the steam and condensing water.

The refrigerating water from the sea is forced through this condenser, by means of a small centrifugal pump, driven by an independent oscillating engine devoted solely to that duty.

The boilers are of peculiar construction, patented by Mr. Dickerson, and are braced for an excessive working pressure. The chief heating surface consists of a great number of inclined water tubes, placed as it were within the furnace itself. The boilers are also provided with a considerable area of superheating surface, which consists of a number of vertical tubes, through which the products of combustion pass on their way to the chimney; the lower end of these tubes enter the crown-sheet of the furnace, and are, of course, surrounded by water. The feed-water is heated by means of casing surrounding the base of the smoke pipe.

The principal dimensions of the boilers are as follows:

Total grate surface,	*144 square feet.
Total heating surface,	2678 " "
Total superheating surface in the superheating tubes,	1132 " "

The average pressure carried during the late trials at the wharf was about 70 lbs. per square inch, and the point of cut-off about *one-tenth* of the length of the stroke. Thus, the well read engineer will see, that in this machinery the attempt was made to carry out the most economical modern practice; all the elements of the best practice of the best known English engineering firms were embodied in this engine, the point of cut-off and the pressure of the steam being carried to extremes.

The engine of the *Winooski* is also the ordinary inclined engine—such as may be seen at most of our ferry boats. The valves are of the usual American equilibrium variety. These valves, and the mechanism which works them, are such as are universally used in paddle wheel steamers in this country, and the valves and valve gear, taken as a whole, is looked upon as one of the best examples of American engineering skill; the result, in fact, of years of experience. The independent cut-off gear is known as the "Stevens," and can only be adjusted (in ordinary practice) by going through quite a lengthy process of changing, pins, eccentrics, and wipers. The principal dimensions of this engine are as follows:

Diameter of cylinder,	4 feet 10 inches.
Length of stroke,	8 " 9 "
Diameter of piston rod,	6½ "
Volume swept by piston at each stroke, exclusive of the rod,	159·53 cubic feet.
Clearance at one end of the cylinder, including steam passage, &c.,	13·52 cubic feet.
Diameter of the double beat steam valves	15½ and 16½ inches.
Diameter of the double beat exhaust valves,	15½ and 16½ "
Diameter of the openings into and out of the cylinder,	393 square inches.
Diameter of air pump,	2 feet 7 inches.
Diameter of circulating pump,	2 " 7 "
Stroke of circulating pump,	4 " 4 "
One barrel used for both pumps.	
Area of refrigerating surface on the tubes of the surface condenser,	2293 square feet.

* This was reduced, during a great portion of the trial, by bricking up the back ends of the grate bar to about 130 square feet.

In short, this engine is a good copy of the ordinary American poppet valve expansion engine, such as is universally used in this country.

The steam is condensed by a surface condenser, the refrigerating water being driven through it by means of a reciprocating pump, driven by the main engine.

The boilers are of the vertical tubular type, such as are universally used in the naval service. The principal dimensions are as follows:

Heating surface in both boilers in 10 furnaces,	375·13	square feet.
Heating surface in both boilers in 10 combustion chambers,	105	" "
Heating surface in both boilers in 10 back connexions,	326·32	" "
Heating surface in both boilers in 10 tube boxes,	647·71	" "
Heating surface in tubes of both boilers, . . .	3453·96	" "
Heating surface in uptakes 9 inches above tubes, .	127 88	" "
Total heating surface in both boilers, . . .	5036	" "
Superheating surface in uptakes of both boilers, .	171	" "
Grate surface in both boilers, ...	200	" "
Cross area of smoke pipe, ...	23·7	" "
Cross area through tubes for draught, . . .	26·6	" "

The paddle-wheels of both vessels are precisely the same, having been built from the same drawings; they are of iron, 26 feet in diameter, with 24 wooden paddles, 9 feet long by 15 inches in width.

During the late trials they were fitted with paddles of the same dimensions and immersion in the water. The condition of the wheels during the late trials was as follows: Diameter over the paddle, 22 feet 6 inches, each paddle 9 feet in length by 7 inches in width; number in each wheel 24; maximum immersion of the lower edge of the paddles 27½ inches.

The useful power developed was therefore measured by the number of revolutions made by the wheels in a given time, and the cost of that power by the quantity of fuel consumed in the furnaces of the boilers. This is a very simple method, as it avoids much calculation. But it should be mentioned, that in order that this method of measuring the relative power of two engines—one working with a very high measure of expansion, and, of course, having a very *ununiform* pressure on the piston, and consequently on the paddles; the other working with an ordinary measure of expansion, and consequently with a much more *uniform* pressure on the piston and the paddles—that the paddles should be so proportioned that the velocity through the water should be uniform. For if this is not the case, as the power required to force the paddles through the water varies as the *cube* of the speed, it will be readily perceived, that if one wheel moves irregularly and the other uniformly, the revolutions of the wheels cannot be an accurate dynamometric test of the relative powers developed. Now, as the wheels of the *Algonquin*, on the dock trials, actually did revolve irregularly, while those of the *Winooski* revolved practically uniformly—owing to the more uniform pressure on her piston—it will be seen that this measure of the power gave less than the true result for the *Algonquin*, in proportion to the more irregular motion of her paddles.*

* The *Algonquin* halted on each centre, while the cranks of the *Winooski* revolved, as far as the eye could detect, with a uniform velocity. At the commencement of the trials, Mr. Isherwood desired to so arrange the paddle surface, that the *Winooski*, burning 1600 lbs. of coal per hour, would make but 13½ revolutions.

The first economy trial between these vessels commenced on Friday afternoon, September 22, 1865.

The *Algonquin* started her engine at 4·47 P. M., and it was kept in continual operation until 11 P. M., Sunday, when her feed-pipe was fractured, and it was necessary to stop the engine.

The engine of the *Winooski* was started at 5·11 P. M. of the same day, and completed the stipulated time of 96 hours, or 4 days.

The conditions of the trial were, that each vessel should burn not exceeding 1600 lbs. per hour, and that the trial should last 96 hours. Both vessels were lashed to the wharf, and the power, as before mentioned, was measured by the revolutions of the wheels.

The following is the data of this trial, extracted from the report of the Naval Engineers to the Secretary of the Navy:

	Winooski.	Algonquin.
Total time of trial in hours,	51	51
Total number of revolutions of wheels,	45,149	44,918
Total number of pounds of anthracite,	80,400	79,239
Average number of revolutions per minute,	14·7564	14·6791
Average number of pounds of coal per hour,	1,576·5	1,553·7
Average pressure of steam in boiler,	16·8	70·79
Average point of cutting off,	0·47†	0·11
Vacuum in condenser in inches of mercury,	27·65	22
Back pressure in cylinder in lbs. per square inch, by indicator,	1·50	4·00
Mean indicated pressure on piston, in pounds per square inch,	24 87	31·06
Indicated horse power,	520·17	500 01
Pounds of coal per hour per indicated horse power,	3·031	3·107
Temperature of feed-water,	112°	158°

Data of the Second Economy Trial, extracted from the report of the Board:

	Winooski.	Algonquin.
Date of commencement, October 23, 1865, P. M.,	4·23	4·22
Duration of experiment in hours and minutes,	96·	69·8
Total number of revolutions,	85,884	62,407
Total number of pounds of coal consumed,	152,015	111,344
Total number of pounds of refuse from coal,	30,400	19,500
Total number of pounds of coal consumed, less refuse,	121,615	91,844
Per centum of refuse,	20	17·51
Average pressure in steam pipe in pounds per square inch,	19·64	71·63
Average point of cutting off the steam,	0·619*	0·132
Average vacuum in condenser, in inches of mercury,	27·80	20·54
Average barometer, (Aneroid,)	29·94	29·94
Average revolutions per minute,	14·9104	15·0450
Average indicated pressure on piston,	26·276	31·6
Average indicated horse power,	545·48	517·31
Pounds of coal consumed per hour,	1,583·4	1,610·5
Pounds of coal consumed per hour, less refuse,	1,266·8	1,348·50
Pounds of coal per hour per indicated horse power,	2·905	3·113
Pounds of coal per hour per indicated horse power, less refuse,	2·322	2·568
Temperature on deck,	53·6°	53·6°
Temperature in fire room,	98°	108·9°
Temperature in engine room,	66·8°	70·1°
Temperature of injection water,	55°	55°
Temperature of discharge water,	85·9°	69·2°
Temperature of feed-water,	104·3°	161·4°

*† See remarks a little further on, in relation to the cut-off.

With respect to the result of the first trial, at the time the *Algonquin* ceased working, she had consumed coal at the rate of 1600 lbs. per hour, less *2525 lbs. charged to her, but not burned, together, it is said, with nearly a full allowance of 1600 lbs. on the fire room floor.

At the time of stopping, the counter of the *Algonquin* marked 47,454 revolutions, and the same time the *Winooski's* counter 47,362 revolutions, being a difference of 92 in favor of the former vessel. Allowing for the difference in time of commencing, the *Winooski* was a little ahead in turns, but she had also burned more coal than the *Algonquin*.

However, the report of the Naval Engineers on this trial states "that the economical performance of each was equal at the time of the failure of the machinery of the *Algonquin*," although, as has been already mentioned, we know, from personal examination, that the *Algonquin* actually made more revolutions than the *Winooski* with the same coal. Let it be assumed, in order to make a clear case, that the report of the Naval Engineers is correct, it will then be interesting to make a comparison, and see how the result stands with regard to the expansive principle.

Analyzing indicator diagrams, taken from both vessels during this late trial, it is seen that the back pressure against the piston of the *Algonquin*, due to the inferior vacuum in the condenser, is about 3·5 lbs. per square inch greater than the same pressure against the piston of the *Winooski*. So the *Algonquin's* engine, in addition to revolving a wheel of the same size, and at the same speed as that of the *Winooski*, it also had to overcome the constant extra resistance of 3·5 lbs. per square inch of the piston. As the mercurial column of the *Algonquin's* vacuum gauge vibrated through several inches, it may be that the estimate of the Board of its mean height, viz: 22 inches, is the nearest correct; however, we estimated it at 20 inches, but it makes no difference which is right, as the indicator diagrams show the exact mean back pressure against the pistons of both vessels, due to the condition of the vacuum in the respective condensers. The condenser gauge fitted to the *Winooski's* condensers, was one of Bourdon's, and the hand only vibrated enough to indicate that the communication to the condenser was unobstructed. Some indicator diagrams taken from the *Algonquin's* cylinder during the trial, show the effect of the back pressure against her piston—in excess of that of the *Winooski*—making the number of strokes per minute, stated by the Board, was to lessen the power of her engines upwards of 60 horses. And an average of several indicator diagrams, taken at intervals during the trial, shows the excessive back pressure in the *Algonquin's* cylinder was equal to a loss of dynamic effect of over 50 horses power. Then, taking the admission of the Board of Engineers that both vessels actually performed the same work with the same coal in turning

* 1600 lbs. was weighed out to each boat per hour; this was dumped in a heap, and used at discretion.

the paddle wheels, it follows, from this cause alone, that the *Algonquin* really developed 50 horses power more than the *Winooski.**

It has been asserted by the Chief of the Steam Bureau, that a loss rather than a gain would have resulted to the *Algonquin* if the vacuum in her condenser had been equal to that in the *Winooski's*. This, he said, would be effected in two ways, namely, the decrease in the temperature of the *Algonquin's* feed-water due to a better vacuum, and the increased "cylinder condensation" also due to a better vacuum.

The usual calculation, however, shows that the loss from these causes would be but a small fraction of the gain in power which would have resulted to the *Algonquin's* engine, had the vacuum in her condenser been equal to that in the condenser of the *Winooski*, viz: 27·65 to 28 inches of mercury—the more so as the comparatively high temperature of the *Algonquin's* feed-water was not due entirely to the poor vacuum, but in a great measure to her feed-water heater. It is believed that at least 30° of the temperature of her feed-water was due to the heater. Another source of loss in the *Algonquin* was the independent circulating engine.

This engine has a cylinder 10 inches in diameter by 7 inches length of stroke; the steam is drawn directly from the boiler and follows the piston full stroke. This engine is attached directly to the axis of the centrifugal pump, and the number of revolutions it made was so great that they could not be accurately counted by the eye. The lowest estimate of the number of revolutions, made by several civilian engineers who saw it, was 400 per minute; the polished brass oil cup on the crank-pin looked like a wheel, so fast did it run.

Let us assume, for the sake of illustration, that it made only 250 per minute, and that the mean pressure of steam on its piston was 25 lbs. per square inch. When it is taken into consideration that the pressure in the *Algonquin's* boilers was some 70 lbs. per square inch, and as the vacuum was deficient, this independent engine was driven to its utmost, this pressure is clearly under the true amount.

Therefore, calculating in the usual way, it is seen that this engine was working up to no less than 22 horse power.

Again: the piston of the main engine of the *Algonquin*, including clearance at the ends, was only moved through 2·6 times more space before the supply of steam from the boiler was cut off, than was moved through in the same time by the piston of the circulating engine. Hence, calculating the quantity of water which passed through this small engine in the form of steam—neglecting condensation—it is found to be about 22 per cent. of the total amount of water evaporated by the boilers of the *Algonquin*. It is, of course, hardly necessary to add that if this great quantity of steam had been put into the main cylinder, where it would have had its efficiency increased by

* Of course, a deduction must be made from this amouut, on account of the lower temperature of the feed-water of *Algonquin*, had the vacuum been equal to *Winooki's*.

expansion, the utter defeat of her competitor would have been the consequence.

The great difference in the power required to circulate the refrigerating water in these vessels, having been noticed at an early stage of the trial, Mr. Isherwood asserted that the power required to work the circulating pump of the *Winooski* "will not amount to one-fourth of one per cent. of the total power." The great disadvantage under which the *Algonquin* worked in this respect is therefore evident. According to this calculation, twenty times more power was required to perform this duty in the *Algonquin* than in the *Winooski*.

It now remains to mention the difference in the character of boilers of the two vessels, with respect to their relative economical evaporative power.

The proportion of the heating surface to the grate surface in the *Winooski's* boiler is 25 to 1; the consumption of coal during the trial [assuming 1600 lbs. per hour to have been consumed] was 8 lbs. per hour per square foot of grate surface, and ·31 lbs. per hour per square foot of heating surface. Referring to an experiment made with a similar boiler in the U. S. "doubled-ender" *Eutaw*, it is seen that at the rate of combustion of 8·36 lbs. of coal per hour per square foot of grate surface, the evaporation was 9·28 lbs. of water from a temperature of 100° per lb. of coal consumed.

In the boilers of the *Algonquin* the ratio of heating to grate surface is 27·7 to 1. Assuming that 1600 lbs. of coal was burned each hour, the rate of consumption was 11·4 lbs. per hour per square foot of grate surface, and ·42 lbs.* per hour per square foot of heating surface. With respect to the evaporative power of these boilers, it will be well, in the first place, to examine the disposition of the heating surface. This consisted almost solely of a series of inclined *water tubes* placed within the furnace, which was made correspondingly high; the superheating tubes are secured, one end in the crown sheet of the furnace, and the other in the shell of the boiler. Through these tubes the products of combustion pass and are collected by a water casing on which the smoke pipe is fitted. As these superheating tubes are quite short, (not over 26 inches long,) and lead straight from the furnace to the chimney, it is clear that, owing to the short distance the hot gases pass over the superheating surface before being discharged into the atmosphere, but little caloric can be imparted from them to the steam outside the superheating tubes. Again, as the lower ends of these tubes are immersed in water, not only will the tubes be cooled by the conducting power of the metal of the tube itself, but if there is the slightest priming the whole of the tubes will be covered with spray. For these reasons, it is evident that a more inefficient superheating apparatus could scarcely be devised. Those who have experience with superheating apparatus are aware how priming, if spray comes in contact with the superheating surface, destroys its efficiency as a superheater. As to the evaporative power under the conditions of the experiment, ample experience warrants that it at least cannot be placed higher than 8 lbs. of water evaporated for each pound of coal burned.

* Including the superheating surface.

The least that can be said for the vertical water tube boiler* of the *Winooski*, is that it is unsurpassed by any type of boiler in use for economic evaporative efficiency under the very favorable conditions of the trial; on the other hand, the boiler of the *Algonquin* may be classed as one of but ordinary economical evaporative power. Hence the steam as delivered to the *Algonquin* engine cost much more in coal than the steam delivered to the *Winooski* engine.

With regard to the superheating of the steam in the two vessels it may be mentioned, that thermometers, inserted in their respective steam pipes, indicated that the temperature was but very little above that which is due to the pressure. On the *Winooski*, the expedient was adopted of carrying the water in the boilers a considerable distance below the upper tube sheet, in order to superheat it by bringing the fire directly in contact with the upper portion of the tubes. This device fully compensated for any gain in this direction obtained on the *Algonquin* as before indicated.

Experiments on a duplicate of the boilers of *Winooski* show that there was no material decrease of evaporative efficiency by carrying the water at the distance below the tube sheet it was carried on the trial.

Yet with all these various sources of loss which did not exist in the *Winooski*, viz: the excessive back pressure in the cylinder, the great quantity of steam wasted by the circulating engine, the loss of effect due to the irregular velocity of the paddles, and the inferior economic evaporative efficiency of the boilers, the Board of Naval Engineers reported, "that the economical performance (*i. e.* work actually done) of the machinery of each was equal at the time of the failure of the machinery."†

The second economy trial was still more decisive in its results than the first. This is, no doubt, due to the fact that the engine of the *Algonquin* had been repacked and the valves ground in. The trial com-

* Whatever may be the deficiencies of this type of boiler with respect to absolute evaporative capacity, it is admitted that for economical evaporation at low rates of combustion, it is unsurpassed.

† On this head the London *Engineer* remarks: "Granting, then, that both engines used the same amount of fuel in doing the same work, in what, it will be asked, lies the superiority? In order to answer this we must first point out that this was not a test of actual economy; it was simply a test of relative economy. Again, Mr. Isherwood holds that the proper point at which to cut off is ·7 of the stroke, and on this principle all the new screw engines of the American Navy have been designed. He admits that a slight saving may be effected—fifteen per cent., or thereabouts—by cutting off at this point, as compared with working the steam full stroke. He also states definitely that by cutting off at $\frac{4}{5}$ths of the stroke, 'the loss of the economy in fuel alone reaches forty-four per cent. of the cost of the power when cutting off at ·7;' that is to say, that an engine cutting off at $\frac{4}{5}$ths is forty-four per cent. less economical than one cutting off at ·7. In the face of this absurb statement we have Mr. Dickerson's very imperfect engine, cutting off very nearly at $\frac{4}{5}$ths, burning precisely the same quantity of fuel as another engine cutting off at ·475. It is also worthy of note that, although the Chief Engineer of the United States Navy pins his faith on this particular cut-off at ·7, as being the most economical possible for all speeds of piston, for all pressures, and for non-condensing as well as condensing engines, he would not adopt it in the *Winooski*, but he did adopt a different grade, ·457, which we, in this country, know to be about the best possible for ordinary condensing engines, with unjacketed cylinders and long strokes. On this point Mr. Isherwood is decidedly beaten."

menced October 23, 1865, at 5 o'clock, P. M. Owing to some misunderstanding between the rival engineers, the *Algonquin's* engine was stopped after it had run some 69 hours of the stipulated 96. Now, the Board of Naval Engineers report that "three hours from the commencement of the trial the fires were in steady action, and the machinery in proper working condition." During the succeeding forty-eight hours, the *Algonquin* gained about 1000 revolutions over the *Winooski*. This seems to be decisive as to the soundness of Mr. Isherwood's views on the subject of expansion, because 48 hours of uninterrupted trial, both vessels during that time consuming the same coal, is just as decisive in pointing out which way the scale inclined, whether for or against Mr. Isherwood's hypothesis on expansion, as though it had been extended over an indefinite period. And, as the power required to revolve the respective wheels varies as the cube of the number of revolutions made in a given time, it will be perceived how very decisive this last trial has been against Mr. Isherwood's theory. The reason why this 48 hours has been selected from the time occupied in performing this experiment, is that during that time the *Algonquin's* engine was operating well—as well as it could be expected to operate; while it is admitted by all that the superior engine of the *Winooski* works as well at the end as at the beginning of the trials, and for the purpose of scientific comparison it would be obviously improper to include that portion of the time during which the *Algonquin* was gradually breathing her last.

No doubt, taking the whole time into consideration, the tables of the Board are correct, but that proves nothing in relation to the question under discussion.

It will be noticed, that the point of cut-off of the *Winooski* is reported by the Board to be different in these two trials, and as the cut-off was not changed, and the indicator cards taken during the two trials are the same, it is necessary that this feature in the report should be explained. The Board report: "The point at which the steam was cut off in the cylinder of the *Winooski* was ascertained by 'hooking on' the eccentric rod and turning the engine by hand, noting exactly on the main guides the point at which the toe of the socket aft left the lifter on the lifting rod. This measurement gave 4 feet 10 inches for the upper stroke, and 6 feet for the lower stroke; which, as the stroke of the piston is 8 feet 9 inches, gave a mean of 0·619. The cut-off of the *Algonquin's* engine, not being a positive, one could not be so measured, but has been computed from the indicator diagrams."

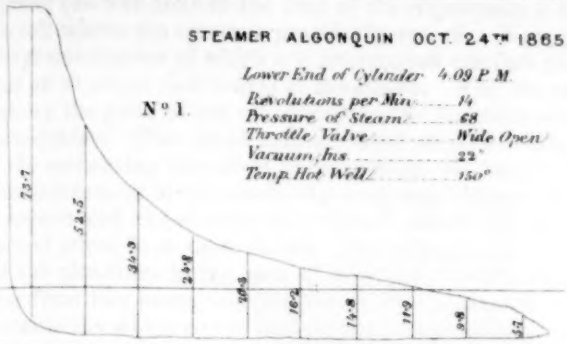
Now, owing to the peculiar action of the *Winooski's* independent cut-off, (the one known as the Stevens,) the steam is practically cut off from the cylinder some time before the valve actually seats itself; for while the valve is almost touching its seat and moving at its *slowest* rate of speed—which is very slow indeed—the piston is moving at its *highest* rate of speed. Again, if the valve is deep on its conical bearing face, this distance is very considerable, *i. e.* the distance moved by the piston after the steam is practically cut off before the valve absolutely seats itself. However, to examine the indicator dia-

STEAMER ALGONQUIN OCT. 24TH 1865.

Lower End of Cylinder 4.09 P.M.

N° 1.

Revolutions per Min	14
Pressure of Steam	68
Throttle Valve	Wide Open
Vacuum, Ins	22"
Temp. Hot Well	150°

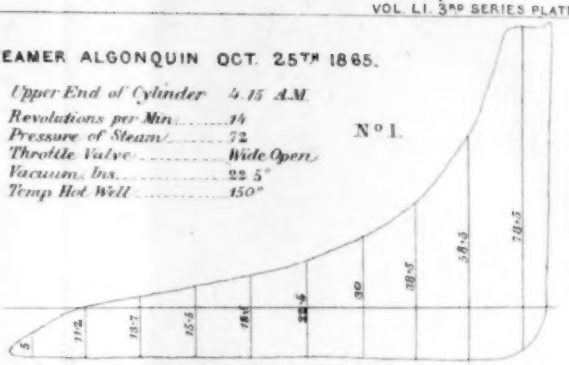


STEAMER ALGONQUIN OCT. 25TH 1865.

Upper End of Cylinder 4.15 A.M.

N° 1.

Revolutions per Min	14
Pressure of Steam	72
Throttle Valve	Wide Open
Vacuum, Ins	22.5"
Temp. Hot Well	150°

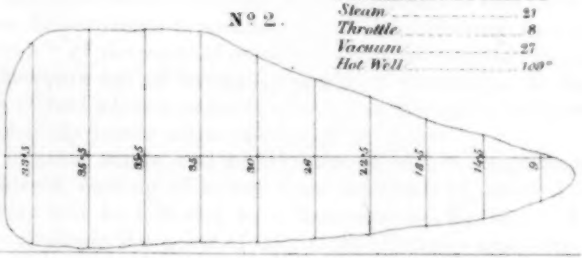


STEAMER WINOOSKI OCT. 24TH 1865.

Upper End of Cylinder 12.30 P.M.

N° 2.

Revolutions	15.5
Steam	21
Throttle	8
Vacuum	27
Hot Well	109°

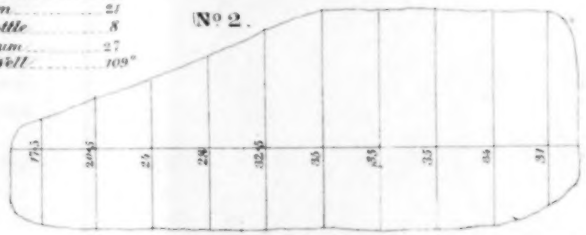


STEAMER WINOOSKI OCT. 24TH 1865.

Lower End of Cylinder 12.30 P.M.

N° 2.

Revolutions	15
Steam	21
Throttle	8
Vacuum	27
Hot Well	109°

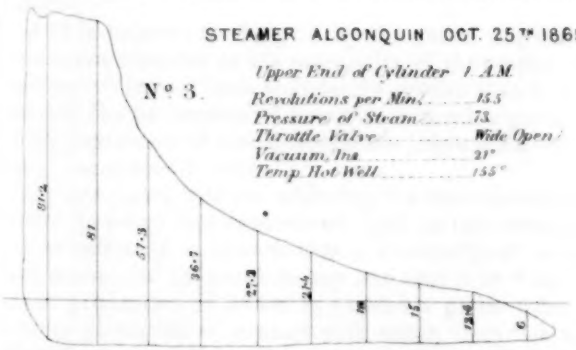


STEAMER ALGONQUIN OCT. 25TH 1865.

Upper End of Cylinder 1 A.M.

N° 3.

Revolutions per Min	15.5
Pressure of Steam	73
Throttle Valve	Wide Open
Vacuum, Ins	21"
Temp. Hot Well	155°

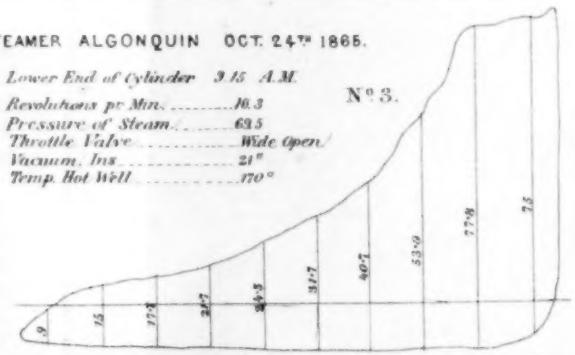


STEAMER ALGONQUIN OCT. 24TH 1865.

Lower End of Cylinder 3.15 A.M.

N° 3.

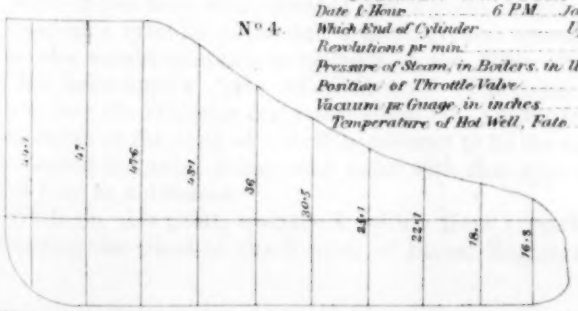
Revolutions per Min	16.3
Pressure of Steam	63.5
Throttle Valve	Wide Open
Vacuum, Ins	21"
Temp. Hot Well	170°



STEAMER WINOOSKI

N° 4.

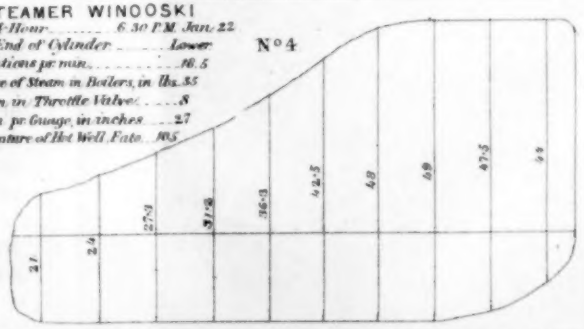
Date & Hour	6 P.M. Jan. 22
Which End of Cylinder	Upper
Revolutions per min.	16
Pressure of Steam, in Boilers, in lbs.	35
Position of Throttle Valve	8
Vacuum per Guage, in inches	26.5
Temperature of Hot Well, Fate	108



STEAMER WINOOSKI

N° 4

Date & Hour	6.30 P.M. Jan. 22
Which End of Cylinder	Lower
Revolutions per min.	16.5
Pressure of Steam in Boilers, in lbs.	35
Position in Throttle Valve	8
Vacuum per Guage, in inches	27
Temperature of Hot Well, Fate	105



grams (as was done in the case of the *Algonquin*) is the only true way to tell where the steam is practically cut off. Now, various indicator diagrams (copies of which are given) show the fact that the steam was cut off at about *four-tenths* of the stroke. Why the expedient of measuring the point of cut off adopted in the last trial was employed, does not appear. The cut-off was the same on both trials.

In estimating the effect of expansion, the loss by clearance at the commencement of the stroke is a very important point; the higher the pressure and the shorter the point of cut-off, the greater will be the loss of effect from these causes. Accordingly, in calculating the effect of the clearance in the case of these two vessels, it is found that the loss from this cause was greatest in the *Algonquin's* engine, not only because the steam was of four times greater density, (which makes one cubic foot in the *Algonquin's* clearance equal to four in the *Winooski's*,) but also because the degree of expansion was very much greater.

Mr. Isherwood's opinion of the result of the well known Erie Expansion Experiments is summed up in the following extract from his report: "*If the point of cut-off be lessened to* $\frac{4}{5}$*ths* (about the point the *Algonquin* cut off during the trials) *of the stroke, the loss of the economy of fuel alone reaches the enormous amount of* 44 *per centum of the cost of the power when cutting off at* $\frac{7}{10}$*ths.*"

In other words, and as Mr. Isherwood has many times emphatically declared, cutting off at less than or beyond $\frac{7}{10}$ths of the stroke of the piston will be followed by a decrease in efficiency. Seven-tenths of the stroke is the point of maximum efficiency according to Mr. Isherwood.

And in relation to the gain by the use of superheated steam, this gentleman remarks, in his summation of the results of the Erie Experiments: "It has been abundantly proved that it is far more economical in the production of power to expend a given quantity of heat in the generation of steam from water, *than in superheating that steam out of contact with water.*"

On this point, without adducing the incontrovertible results of extended practice and experiment, both in this country and Europe, it will be sufficient to remark that a knowledge of elementary physical laws cannot fail to prove to any one that it is "far more economical in the production of power to expend a given quantity of heat," in heating steam out of contact with water, than "in the generation of steam from water."

After it has been demonstrated that a given weight of steam in the *Algonquin's* cylinder performed a much greater amount of work than the same weight of steam in cylinder of the *Winooski*, what becomes of Mr. Isherwood's $\frac{7}{10}$*ths cut-off theory?* The more so, as in these trials, (see the indicator diagrams, Plate III.,) so far from hazarding a completion at the point of cut-off he assumes to be the most economical, he adopted the usual commercial point with that type of engine, viz: from *four* to *five-tenths*.

While on this point, we cannot refrain from remarking, that even supposing the Chief of the Bureau of Steam Engineering had much

stronger grounds to sustain this theory, he would scarcely have been justified in proportioning the engines of the entire screw navy in accordance with it. Indeed, even if results had sustained this wide departure from the most successful practice of the best engineers in the world, such a proceeding would scarcely be justified, but it is well known that the results of the machinery of the U. S. screw vessels fitted with engines planned at the Navy Department in accordance with this theory, have given results much below the average of naval practice, both here and in Europe.* It is a matter for regret that conditions of the innumerable and exceeding costly experiments which have been conducted by direction of the Navy Department during the past four or five years, have not been governed by the advice and experience of a Board composed of our best phycisists and engineers, instead of depending solely on the wisdom of one man; had the course we have mentioned been adopted, it cannot be doubted that the results as regards the increase of our knowledge of steam engineering would have been very great.

But Mr. Isherwood has made these costly experiments—for the most part mere repetitions of each other—the basis of an endless amount of reasoning,† metaphysical reasoning, too, we may almost assert, by which he endeavors to explain the relation of cause and effect, instead of allowing the "experiments" to speak for themselves.

With respect to the rival engines, it should be remarked, that the *Winooski's* is constructed on old and well tried plans; it is the engine which has so great celebrity throughout the world, as the American poppet valve expansive engine.

It was used long before our time and is one of the most marked triumphs of American engineering skill. Indeed, even the point of cut-off, where one would naturally suppose, if any where, a departure would be made from the average practice, was fixed at the usual point in American paddle-wheel engineering; in fact, at the usual point in the paddle-wheel practice of the world.

Hence, nobody, except one not posted in the antiquities of the profession, could suppose that there was anything new in the design of this engine.

* The machinery of the *Winooski* class (paddle vessels) does not materially differ from the usual practice, except that the cylinders are smaller than usual for the boiler power and speed of the piston. The following facts will enable those familiar with navigation to perceive that the performance of the *Winooski* on the late speed trial was not equal to the results usually attained with machinery of much less weight and with less boiler capacity. Length, 240 feet; breadth at load line, 35 feet; draft, (mean,) 8 feet 4 inches; greatest immersed section, 263·8 square feet; average pressure in boilers, 38 to 40 lbs. per square inch; average revolutions, 21·5; average speed, 11·6 knots; total weight of machinery, including water in boilers, 623,918 lbs.; without water, 541,718 lbs.

† The following extract from the London *Engineer* exhibits the opinion so generally entertained on this subject: "Mr. Isherwood's work is so well written, and the figures it contains are so skilfully prepared, and so apparently trustworthy, that many of the younger members of the profession, both here and abroad, have been misled, and others older and wiser have been inclined to doubt the evidence of their own senses and the experience of a lifetime, when opposed to the reasonings of a theorist. The Washington trial, (*Algonquin* and *Winooski*,) short as it was, has utterly demolished Mr. Isherwood's arguments, and proved to demonstration the accuracy of the principles adopted by our most successful engineers for years past."

On the contrary, the machinery of the *Algonquin*, in those parts which govern the making, using, and condensing the steam, is full of novelties. Accordingly, a very mediocre result may be looked upon as a tolerably respectable performance. The contractor of the *Algonquin*, of course, relied on running his engine with a very short cut-off, against another engine cutting off at the point which Mr. Isherwood asserts is the most economical, viz: $\frac{7}{10}$ths of the stroke. On the contrary, as will be seen by inspection of the indicator diagrams, he failed to put his theory to the test.

The diagrams marked Nos. 1 and 3 were taken from the *Algonquin's* cylinder during the dock trials with the *Winooski;* diagrams No. 2 were taken at the same time from the *Winooski's* cylinder, and diagrams No. 4 were also taken from the *Winooski* during a "dock trial" which occurred a few days previous to the trial on Long Island Sound.

By comparing these diagrams with such a diagram as would have been given if the steam had been expanded during but $\frac{3}{10}$ths of the stroke, it will be seen how very far the measure of expansion shown by the *Winooski's* diagrams is from the theory of Mr. Isherwood. Of course, the *Winooski* would have given such a diagram, (*i. e.* one showing the steam to have been expanded during but $\frac{3}{10}$ths of the stroke,) if the $\frac{7}{10}$ths cut-off theory, which Mr. Isherwood claims to have established, at the expense of the government coal yard to be the point of maximum efficiency, had been put to the test. If this had been done, it is very plain what the result would have been; of course, the *Winooski* would have been beaten worse than she really was.*

The trial was, therefore, between an engine with a very short cut-off and of novel construction, and an engine constructed on old and well established plans, cutting off at the usual point. But, nevertheless, as has been shown, it has proved that Mr. Isherwood's conclusions in relation to his innumerable government expansion experiments are fallacious.

Notes on the Origin of Several Mechanical Inventions, and their subsequent application to different purposes. By J. C. Dyer.

From Newton's London Journal of Arts, January, 1866.

The Employment of Steel for Transferring Engravings.—At the beginning of this century, upon the death of Washington, medals to commemorate that event being called for, Mr. Jacob Perkins (then a silversmith at Newburyport, near Boston,) undertook to supply them, and, as they were required in large numbers speedily, he devised a summary process of transferring the engraved design, from prepared steel dies, or stamps, by which he obtained several from one original die, and thus a vast number of medals were rapidly produced. Shortly after, Mr. Perkins applied the same principle of transferring engravings for bank notes, on which very elaborate designs were printed, to prevent or render their being forged very difficult by the hand of the engraver. To effect this, he procured cast steel plates, and de-

* The pressures opposite the ordinates in the diagrams were measured from the original. The diagrams are two-thirds the original size. "Position of throttle valve 8," diagrams No. 4, means, wide open.

carbonated their surfaces to the depth of about one-sixteenth of an inch, which were thus converted into *very soft* and *pure iron;* the letters and designs for the notes being then engraved upon them, they were case-hardened and tempered for *use*, but in lieu of printing from these plates they were used as dies for making others to print with. His next process was to prepare a cast steel cylinder, which, in like manner, was decarbonated at the surface, and then, under a strong traversing pressure, it was rolled over the letters and figures engraved on the hardened plate, and these engravings were taken up in relief on the surface of the soft cylinder. This cylinder being then hardened and tempered, was used to transfer, by means of the same traversing pressure, the entire work upon its surface, to any number of copper or soft steel plates for printing with.

The adoption of this plan by several banks, for having very elaborate engravings on their notes, turned the counterfeiters upon other banks, whose notes would be so much more readily forged, which led to an extended demand by the other banks.

In the year 1809 Mr. Perkins communicated to me the details of his process of transferring engravings, with a view to having the invention patented in England for our joint account. From the success of his plan in America its adoption here was anticipated, and still further development of it looked for from the higher state of the graphic arts in London. With this view I took out patents, and minutely specified "the method of carrying the invention into effect." A very beautiful design was then obtained from the classic pencil of the late Sir R. Smirk, R. A., which was engraved by Reimback, on prepared steel, for printing bank notes. But I could not succeed at that time to induce the Bank of England or any other bank to adopt the plan, nor could the booksellers then be made to perceive the importance of the transferring system for illustrating books, for which it has since been so extensively used. The time had not arrived when public attention could be drawn to the bank note forgeries as a national evil, and the disgrace of hanging men for a feat so readily performed as that of forging the one-pound notes then in general circulation. If any excuse can be offered for this apathy, it may be said that the passions and interests connected with the war, together with those yet more embarrassing that arose from the transitions from war to peace, caused such disturbances in the circulating medium and in the general interests of commerce and industry, that it became very difficult to awaken public attention to the great scandal of relying solely upon the gallows for preventing forgeries.

It has been above shown that Perkins' invention was not for engraving on steel plates for printing, nor for engraving upon steel at all, but rather for engraving on soft iron of homogeneous structure. It was found that all wrought iron is more or less fibrous and unfit to receive delicate engravings, and that by decarbonating the surface of cast steel a pure iron surface was obtained, and this being engraved on, was case-hardened and used for transferring and printing as before stated. This should be kept in view, because many persons have supposed that the invention of Perkins was merely the substitution of

steel in the place of copper for engraving upon; such a substitution of the one metal for the other would not be an invention in any fair sense of the word. But his method of obtaining soft surfaces to receive the work, converting these surfaces back into steel, and then transferring the engravings to other plates for printing, comprised together a series of novel processes which confer lasting honor upon the inventor.

After the transition period, having better hopes of success, I recommended Mr. Perkins to come over himself and explain his system, and aid the artists here in putting it into operation. Accordingly, in the year 1820, Mr. Perkins came to England, and, being over sanguine, brought a large staff of able artists, mechanics, &c., but he could not bring any money to aid in establishing his intended works in London. He had assumed that capital could always be obtained in England for conducting any safe and profitable schemes. Now, the matter of proving his to be such was not easy to establish with the *moneyed class;* so to me alone, not of that class, he had to look for the entire expenses of his mission, and this I could only bear for a few months. After some time, the late Mr. Charles Heath, the eminent engraver, was induced to join Mr. Perkins and become a partner in the engraving works which were then commenced in Fleet Street, and are still continued by their successors.

Besides the printing on paper, Mr. Perkins' system of transferring has been since very extensively employed for calico printing, and in later years we have also seen his process employed to a vast extent in many other departments of the graphic art, such as post-office and receipt stamps, and other prints that are required in greater numbers than could be produced by other means than steel plates or stamps. His system of engraving on steel has at length become a great artistic power, the wide-spread increase of which has given employment to labor and capital to a vast extent in the several branches of art before stated, and from which I believe many large fortunes have been made, but little other than "toil and trouble" ever accrued to the inventor of them.

When any important discoveries in physical science are made they never die, whatever may chance to their authors. The new facts brought before the public go forth like seeds cast upon a fertile soil, yielding the fruits of continual progress among the families of men who seek improvement. It seems only just, then, that each generation should transmit to the next some record of the names of those contemporaries to whose genius and talents all nations are indebted for such discoveries. Wherefore, in addition to the four distinguished inventors brought to the notice of this Society in my former papers, I have in the present one aimed to place that of Jacob Perkins as a worthy contributor to the advance of those branches of art to which his inventions have been applied.

On the Compression of Water.—In tracing the progress of steel engraving, I had no thought of giving a general account of Mr. Perkins' researches in physical science, yet it may not be out of place to notice one or two other of his discoveries.

1. His experiments on the compressibility of water (made some time before he left America) were to test the correctness of the doctrine founded on the Florentine experiments, that water was a non-elastic body, which was then generally taught in the schools and elementary works. At that time Mr. Perkins had never heard of the experiments of Canton (made some fifty years before) which had established the compressibility of water. Although by Mr. Perkins' experiments its discovery was not *strictly new*, yet they were of high scientific value, because of the widely different compressing forces employed by him and by Canton, the latter having applied the pressure from half an atmosphere to two atmospheres, say from seven and a half to thirty pounds a square inch, whilst that employed by Perkins was from fifty to four hundred atmospheres, or from 750 lbs. to 6000 lbs. per inch. The same rate of compression appeared in all his experiments, which corresponded with that shown by Canton's experiments, and in all of which the water was compressed in volume directly as the compressing forces.

The apparatus employed by Perkins was first a cast iron cylinder, about three inches thick, with a movable top of equal strength; this, filled with water, had a force pump (as in the hydraulic press) to measure the pressure within by the leverage and size of the induction pipe. 2d. A small brass cylinder, with a piston to slide in it, water-tight, about three-quarters of an inch diameter, and to have a column of water ten inches long under the piston. The piston rod, graduated to divisions of a hundred to the inch, had a sliding ring on it, to be pressed upon the rod as it was forced down upon the enclosed water, thus marking in the hundredths of an inch the descent of the rod; the brass cylinder being under the same pressure inside and out, was not subject to any strain to alter its capacity. 3d. When the external pressure was removed, the water in the brass cylinder expanding to its original length and raising the piston rod, would, of course, mark the greatest compression effected. In each experiment the diminished bulk of water was directly as the pressure applied, and under the pressure of 100 atmospheres, the bulk of the water was reduced one part in a hundred, and, as before mentioned, this rate proved to be the same as that shown by the experiments of Canton. Some time after Professor Oersted made similar experiments, by employing a stout glass vessel and using a column of mercury to give the pressure, having the like inside cylinder of Perkins to mark the result, which confirmed the same rate as that shown by Perkins and Canton.

On Perkins' Steam Gun.—Mr. Perkins conceived the idea of employing steam at a very high pressure for discharging projectiles with greater rapidity and effect than could be done by the common use of gunpowder. To effect this object, he devised a plan for heating water more intensely than could be done by any boilers then known, viz: that of employing a great number of iron or copper tubes, with their ends fastened into plates, with chambers, or cavities, for receiving the water at one end and emitting the steam at the other.

This apparatus was placed in the midst of a furnace for the heat to

act directly on the water in the tubes, and thus, as Mr. Perkins phrases it, the water could be made red-hot, and flash into steam with a force exceeding that of gunpowder. Then a gun barrel, with its breech opposite the valve opening from the steam chamber, and an apparatus for conducting the balls into the space between the breech of the barrel and the outlet of the steam, and the valve opening at the same time, the steam issued and propelled the balls through the gun in rapid succession with a force about equal to common powder, which could be continued as long as the heat of the furnace could keep up the pressure. He found that from fifty to one hundred balls per minute were shot forth about one hundred yards to a target, with a force nearly equal to that of a common musket, and, of course, by having ten such guns fixed to the same furnace, from 500 to 1000 balls might be discharged per minute. His experiments were witnessed by the Duke of Wellington and many other eminent men, who took much interest in them.

The non-adoption of his system arose from several radical defects in it—first, the danger from fire of having such a cumbrous furnace on a ship; second, the time required to get up the steam in case of sudden encounter with an enemy, which might lead to a surrender before a shot could be thrown from the steam battery; third, by unequal heating, the tubes sometimes gave way, allowing the water to escape, and though the quantity being small would not cause explosions, leaks would deaden the fire and stop the action of the guns, and any suspension in the midst of action must be fatal to the ship using such a weapon. Still, the after interest attached to the plan of the tubular boilers came from reversing the scheme used by Perkins, viz: employing the tubes as flues for the fire, to convey the heat through the tubes to the water surrounding; then, in an outer boiler, by this method, without damaging the tubes, it is found that high-pressure steam can be employed with safety and advantage, so that Mr. Perkins' invention was not barren to the outer world, since his tubular boilers led to their extended employment in railway and steamboat engines, and were, I believe, first employed by Stephenson a few years after the steam-gun experiments had been put *hors de combat*.

NOTE.—Although it is needless to describe the process of case-hardening, so generally known, it may be as well to explain that of decarbonizing the steel plates for engraving. This process is as follows: The prepared steel plates are placed in a cast iron box, and covered about an inch deep with an oxide of iron, prepared by subjecting iron filings to an alternate wetting and drying until they are mostly converted into red oxide. Over this covering a clay luting is placed, so as to exclude the air, and the box is then placed in a furnace and kept at a red heat for about sixty hours, when the oxide in contact with the steel will have taken up the carbon from its surface to the depth of about one-sixteenth of an inch, and thus converted the surface into pure iron, as mentioned in the text.

Proc. Manchester Philos. Soc.

Fire-damp in Coal Mines.

From the London Chemical News, No. 309.

Mr. G. F. Ansell has sent to a contemporary the following account of his mode of applying the law of diffusion to the indication of the

presence and amount of fire-damp: "Gases would appear to be formed of minute atoms, which have motion amongst themselves, rapid or slow, in proportion to the density of the gas experimented upon. This motion of the atoms is not confined to each individual gas, but the atoms of one gas pass freely through and amongst the atoms of another gas, thus producing a perfect mixture of any two gases which are so circumstanced as to admit of the requisite motion. The atoms of a gas are not arrested in their motion by septa of porous substances, that is, substances impervious in the ordinary acceptation, but not absolutely so. Such substances include thin india rubber, artificially prepared graphite, unglazed earthenware, &c. The law of diffusion, as educed by Mr. Thomas Graham, F.R.S., would appear to be as follows: A gas diffuses into another gas or into space in the inverse ratio to the square root of its density. In the application of this law to the indication of the presence of fire-damp, I follow my original thought and use india rubber. I fill a balloon of thin india rubber (just such a balloon as that used by children for a play-thing) with atmospheric air, and I place it under a lever. If now the apparatus be carried into a mine containing fire-damp, the fire-damp diffuses into the balloon, in accordance with the above law, quicker than the atmospheric air diffuses out from the balloon, and the result is that there is an increase of volume within the balloon, and this causes expansion, just as would occur if so much air was forced into it. I cause this increase of size to move a lever, and thereby to make a galvanic circuit, and so to telegraph to a distance, while it also rings a bell on the spot. This particular arrangement is intended to give warning of a slow accumulation of fire-damp, and in practice it answers perfectly, giving at each interval of an hour the increasing amount per cent. of fire-damp present at that part of the mine. Supposing the atmosphere, then, to remain without alteration, the balloon remains of the same size; consequently the alarum would ring continuously for several days; but if the mine were purified, the balloon would shrink in consequence of diffusion, and the alarum would cease. If it be desired to give instant notice to the men at work, or to the people above ground, from the working place I use a porous battery cell, which, with a small column of mercury, gives warning in a few seconds of a sudden irruption of fire-damp. The action of this instrument is so immediate that, unless seen, it would appear incredible; it is, nevertheless, trustworthy and certain. Supposing the atmosphere which has caused the indication to remain unaltered, then the instrument empties itself by effusion, and the indicator returns to the original zero, and remains at that point until the mine is ventilated, when the indicator retires from zero, thus indicating the purification of the dangerous place. These remarks also apply to the pocket instrument described below. The instruments above spoken of are intended to give warning alone; but if it be desired for the information of viewers, inspectors, owners, and others to ascertain the amount per cent. of fire-damp present in the air of mines, I vary the form of my apparatus, but the most convenient form is that which is assumed in the small aneroid barometer for

the waistcoat pocket. The mercurial barometer, when fitted with the necessary accompaniments, gives very satisfactory results, as also does a column of mercury not representing a barometer. As regards the aneroid barometer, I remove the brass back, and replace it by a piece of porous tile—the ordinary biscuit-ware of Wedgewood. In my first experiments I used a piece of a broken flower-pot, which gave as good result as could be wished for. The instrument so completed, with a few additional and purely mechanical arrangements, which I would describe were there space in this letter, may be used as an ordinary aneroid barometer, but at the time of using it, to tell the amount of fire-damp present, it is necessary to close a valve by a small screw. Then having read the point at which the barometer stands, and noting this as the zero to remove a brass cap, which protects the porous tile, and if there be any fire-damp present the hand travels over the face of the dial, because the diffusion of the fire-damp into the chamber of the aneroid barometer causes an increased volume, which, being compelled to occupy a fixed space, causes pressure on the partly exhausted chamber within that space, and thus causes the hand to move over the face of the dial, indicating unfailingly the amount per cent. of explosive gas. In round numbers, 1 per cent. of gas is equal to ·01 inch, and 10 per cent. of gas to 0·10 inch on the aneroid barometer. The following results were obtained in the presence of experienced miners. I will, for this occasion, call my indicator an aneroid barometer: Aneroid barometer indicated 1·50 per cent. of fire-damp; the Davy lamp gave no indication. Aneroid barometer indicated 3·00 per cent. of fire-damp; the gas could be detected by the Davy lamp, which gave a small pale-blue flame. Aneroid barometer indicated 8·00 per cent. of fire-damp; the Davy lamp exploded feebly. Aneroid barometer indicated 10·00 per cent. of fire-damp; the Davy lamp exploded fiercely. Aneroid barometer indicated 6·00 per cent. of fire-damp; the Davy lamp did not explode, but flame elongated greatly."

Specific Gravity of the Ocean and Sea Temperature.

From the London Reader, September, 1865.

The twelfth number of *The Meteorological Papers*, published by the authority of the Board of Trade, which we have just received, contains an important paper under the above title, in which is collected together a mass of valuable facts.

The observations of specific gravity, exceeding 50,000 in number, have, in *every case*, been reduced to the temperature of 62°. All the observations in each square of 10° of latitude and longitude have been collected and meaned; and these means, both specific gravities and temperatures, are shown on an outline chart of the world.

Atlantic.—The mean specific gravity of the whole of the North Atlantic, from the Equator to latitude 50°, is 1·02664, while that of the South Atlantic, between the corresponding parallels, is 1·02676, showing an excess on the side of the waters south of the Equator, but only

of ·00012. The accession of the River Plate has considerable influence in diminishing the density of the sea in its vicinity, and by omitting all observations above 30° north and 30° south, the mean densities become, respectively, 1·0267 and 1·0271; that is to say, between the Equator and 30° the southern waters are heavier than the northern by ·0004. This difference is less than has hitherto been generally supposed, and even *this* exists only between the Equator and 20°, and is chiefly occasioned by the greatly diminished density of the water between the Equator and 10° north in the belt of equatorial calms and rains. Though but little *heavier*, the South Atlantic is decidedly *colder* than the North, nearly 5°, their mean temperatures being 71°·6 and 66°·7, respectively, and that this difference is tolerably uniform, parallel for parallel, is rendered evident by some thermal curves which accompany the paper. Changes of temperature in sea-water are frequently abrupt. When H. M. S. *Nile* was going from Halifax to Bermuda, in May, 1861, Admiral Milne found the temperature 70° at the bow, while only 40° at the stern, as he entered the Gulf Stream. In illustration of the effect of heavy rains, in at least temporarily diminishing the specific gravity of the surface, a most remarkable instance was observed by Dr. C. K. Ord, of H. M. S. *Hermes* when that ship was lying in Simon's Bay, in August, 1859. On the 4th of that month, at 9 A. M., the specific gravity was 1·0266, and in an hour it was reduced by the heavy rain that fell to 1·0193, the water becoming "brown in color, merely brackish in taste, and its current setting distinctly outwards." By noon the density had increased to 1·0253, and at 3 P. M. the surface had recovered its former density of 1·0266. The next day the specific gravity was again reduced by heavy rain, and again rose.

Mediterranean.—The mean specific gravity of the whole of the Mediterranean, derived from about 600 observations, is 1·0289. The mean density increases gradually from west to east; the observations to the west of longitude 10° east giving a mean density of 1·0286, while between 10° east and 30° east the mean is 1·0291, showing an excess of ·0005 on the side of the eastern half of the sea. The average temperature at the surface is 67°·3, (the mean of *all* observations.) The highest temperature recorded is 79°, and the lowest recorded is 53°.

Dardanelles and Black Sea.—The Peninsular and Oriental Company's steamer *Colombo*, while passing through the Straits of the Black Sea, found the specific gravity decrease from 1·0278 to 1·0162. The mean of all the observations in the Black Sea (nearly 200) shows an average density of only 1·0143; the maximum recorded is 1·0209; the minimum* 1·0114. The large influx of fresh water from the great rivers which discharge themselves into the Black Sea, is no doubt the cause of its diminished density, as compared with the Mediterranean. Its mean temperature is 56°·8, or 10°·5 lower than that of the Mediterranean.

North Sea and Baltic.—There is a very marked difference between

* Except off the mouths of the rivers.

the mean densities of the North Sea and the Baltic; for while the density of the former differs but little from that of the Atlantic Ocean generally, the specific gravity of the Baltic, as derived from about 100 observations, is even less than that of the Black Sea.

North Sea, . . .	Mean specific gravity, . . .	1·0261
	Maximum "	1·0280
	Minimum "	1·0199
Baltic, ...	Mean specific gravity, . . .	1·0086
	Maximum "	1·0232
	Minimum "	1·0003

The mean of the observations in the western half of the sea (longitude 10° to 20° east) is 1·0112, while the observations to the east of longitude 20° show a mean density of only 1·0042. The temperature of the water appears to decrease eastward, but the observations are not sufficiently numerous to be of *much* value.

Pacific.—It is remarkable that, although the waters of the North and South Atlantic do not, upon the whole, appear to differ much in density from each other, yet the specific gravity of the South Pacific does seem to exceed that of the North, parallel for parallel. As in the case of the Atlantic, the mean surface temperature of the North Pacific exceeds that of the South, but the excess is neither so great nor so uniform. It should be remembered, however, that the Pacific observations are not so numerous as those made in the Atlantic, nor do they extend over quite the whole surface of the ocean. Taking the same limits as in the Atlantic, namely, 50° north and 50° south, the specific gravity of the North Pacific is to that of the South Pacific as 1·0254 to 1·0265, an excess of ·0011 on the side of the South. The mean temperature of the North Pacific is 69°·9, (as far as present observations go;) that of the South is 67°·7, two degrees lower. The limits of longitude adopted in calculating these averages for the Pacific are 70° west and 140° east. Of the three oceans south of the Equator, the Atlantic, the Pacific, and the Indian, the Atlantic is the heaviest and the coldest; while the Indian is the lightest and the warmest, and the Pacific is between the two, as below.

South Atlantic, . .	Specific gravity, . . .	1·02676
	Temperature, ...	66°·66
South Pacific, . .	Specific gravity, . . .	1·02658
	Temperature, ...	67°·70
South Indian, . .	Specific gravity, . . .	1·02630
	Temperature, ...	69°·28

The North Atlantic *appears* to be both heavier and warmer than the North Pacific, but observations are wanting in the middle of the Pacific, where the density is probably greater than in other parts of that ocean. The result of the observations, as far as they go, is as follows:

North Atlantic, . .	Specific gravity, . . .	1·02664
	Temperature, ...	71°·56
North Pacific, . .	Specific gravity, . . .	1·02548
	Temperature, ...	69°·49

From its local peculiarities, the Indian Ocean, north of the Equator, cannot be compared with either the Atlantic or Pacific.

Sea of Japan, Yellow Sea, &c.—The density of the water (at surface) in the neighborhood of the Japan Islands and near the east coast of China and Chinese Tartary is somewhat variable. The greatest recorded in these seas is 1·0354, found in 40° 40′ north, 138° 6′ east; but upon the whole the mean specific gravity is not high; and near the mouths of the larger river, especially in the Yang-tse-Kiang, it is very low indeed. Near the mouth of the Peiho also it was on one occasion found to be as low as 1·0053. The sea-water temperatures generally appear rather high for the latitudes. The range of temperature, especially near the coast, is considerable. In the Gulf of Pe-Chili a range of 52° has been observed, 82° being the highest and 30° the lowest temperature recorded. The occasionally very low temperatures in this locality seem to be caused by the ice brought down by the Peiho River.

Red Sea.—The mean of some 200 observations gives 1·0286 as the mean density of the Red Sea. The density seems to be greatest in the northern parts of the sea, and to decrease gradually southwards towards Aden. The maximum observed is 1·0321, in the Bay of Suez; the minimum 1·0252, near Aden. Dividing the sea into two parts, north and south latitude 20°, we have the following result:

Mean density of the whole (as above), . . .	1·0286
" " northern half, . . .	1·0297
" " southern half, . . .	1·0272

being an excess of ·0025 on the side of northern half. The mean temperature of the Red Sea is 79°·3· Above latitude 20° it is 77°·4, and (the mean of the observations) below that latitude is 81°·5. The highest temperature recorded is 94°.* Temperatures as high as 90° occur not unfrequently. The lowest temperature reported is 64°.†

Indian Ocean and adjacent Seas.—In the Indian Ocean, including under that head the sea as far as 50° south and 140° east, the region (or line) of lowest specific gravity appears to be near the Equator, or a little to the south of it, whereas, in both the Atlantic and Pacific, the line of least density is to the north of the Equator in the belt of equatorial rains and calms. There is a marked decrease in density towards the east in the Bay of Bengal and towards Sumatra, occasioned no doubt by the accession of the fresh water from the rivers Ganges, Mahanuddy, and Irawaddy; but taking the means of zones of 10° there is but little difference in either the specific gravity or temperature from 20° north to 20° south. In the neighborhood of Sumatra and Java, in Banca, Sunda, and Gaspar Straits, the specific gravity is exceedingly variable. Though the specific gravity of the South Indian Ocean is less on the whole than that either of the South Atlantic or the South Pacific, some of the highest densities on record have been found in the South Indian. Captain Heddle of the *Calliance*, when going from Melbourne to Calcutta, between 30° and 10° south latitude, 100° and 90° east longitude, found two of 1·0349 and

* Steamer *European* at Aden, September 2, 1857. (Captain Maury mentions 95° as a not uncommon temperature in the Red Sea.)

† H. M. S. *Cyclops*.

1·0362, respectively. The last is the highest observation (well authenticated) on record, with the exception of Captain Harrington's 1·0442 to the southward of Australia.

The paper concludes with the following short summary of results: In conclusion, the result of the whole inquiry serves to show that the *chief* differences in oceanic specific gravity arise from local or special circumstances. It is high in regions where evaporation is rapid, as in the trade-winds, and low in those parts of the ocean where much rain falls. It is highest of all (on the average) in arms of the sea, such as the Red Sea, where there are no rivers and but little rain; and lowest near the mouths of great rivers, such as the St. Lawrence or the Plate, or in seas like the Black Sea and the Baltic, where the accession of fresh water is great. It is low also in high latitude in the vicinity of ice. The highest surface temperature anywhere recorded is 94° in the Red Sea near Aden. The highest surface temperatures recorded elsewhere* are 88° and 89°. These have been found not unfrequently in the Indian Ocean near the Equator. Captain Maury speaks of a temperature of 95° as being not uncommon in the Red Sea, but there is no record here of any temperature above 94°.

On some of the most Important Chemical Discoveries made within the last Two Years. By Dr. F. Crace Calvert, F.R.S., F.C.S.

Lecture I.

Continued from page 202.

From the London Journal of the Society of Arts, No. 671.

The next discovery to which I desire to draw your attention is still in its infancy; but I am induced to refer to it from two considerations. The first, that it may render great service to society by enabling us to preserve the lives of many thousands of our fellow-creatures in our coal mines and other underground works, and, also, because it is a beautiful illustration of the amount of knowledge that a man requires at the present day either to understand or appreciate fully the discoveries of others, or to enable him to attempt any original invention of his own. Unless a person possesses the rudiments of the leading sciences of the day he will never be anything but an imitator, and will never succeed in improving the inventions already made. It is certainly most interesting to witness how the most abstruse branches of science are brought to bear on arts and manufactures, and no better example can be given than the application of electricity under various forms to what is commonly called the telegraph. The invention which I am about to bring to your notice is due to M. Dumas, a young French engineer, and to M. Brequet, of Paris, who is also practically connected with telegraphy. To enable these gentlemen to carry out their discovery they have had to study, and be perfectly acquainted with, the researches of many of the most eminent men that science has produced during the last half century. Thus they employ the galvanic battery which was discovered by Galvani, and perfected by many

* With the exception of a temperature of 91°, once recorded in square 62.

philosophers, until brought at last to its present perfection. They use a mixture of bichromate of potash and sulphuric acid in a Bunsen battery. They have also had recourse to magneto-electricity, first discovered by Faraday, and brought to its present perfection by the researches of MM. Nobili, Mason, Becquerel, Joule, and others, and to enable them to construct their apparatus they have applied, with great ingenuity, the inductive coil, the result of many successive discoveries, and brought to great perfection by Ruhmkorff, the vibrating interrupter of Dancer, and also the condenser of Fiquier. Further, they must have had the knowledge of the stratified light and the application of it by Gassiot: the fluorescence of light by Stokes and Becquerel, and their applications to glass by Geissler. All these facts prove the correctness of my statement, how vast is the amount of knowledge required to make a little discovery. The apparatus invented by these gentlemen is portable, for a miner carries on his back the above-mentioned galvanic battery, and this generates the force required, which is multiplied, increased, and brought to light by the Ruhmkorff coil, which is also confined in the same leather case, occupying only six inches; the magneto-electricity passes through wires covered by vulcanized india rubber, and these are in connexion with a thick glass tube, in which a vacuum has been made, and this contains a fluorescent tube of Geissler, which becomes luminous or fluorescent by the passage of the electricity through it, generated by the coil and the battery.

Although both light and electricity are most interesting subjects, and could well be made the subject of many lectures, still I am bound to leave them on one side, and draw your attention to other facts deserving of notice. It is well known to all chemists and philosophers that matter has a great tendency to assume a geometrical or crystalline form, and that whenever the atoms of matter are sufficiently free for molecular attraction to have its full influences, attraction between the atoms of matter takes place, and gives birth to well defined crystals. The following examples can be cited: The slow condensation of the vapor of iodine, which gives rise to well defined crystals, as well as those of camphor and other volatile bodies. When sulphur, bismuth, and other substances are melted, and allowed to cool slowly, and the excess of the fluid remaining among the crystals is poured off, well defined crystals are found to exist in the mass, which apparently would have disappeared had not the excess of fluids been poured off, for in this case the molecules of the remaining fluid mass would have solidified among the crystals, and would have prevented the observer from seeing that the molecules when freed in the fused mass had assumed a crystalline form. The tendency of molecules to assume a geometrical form presents in many instances curious phenomena. Thus, for example, a vessel may contain acetic and carbolic acids; and if, say at a temperature of 40° or 50°, a crystal of either of those substances is placed in contact with its own fluid, the entire bulk of fluid passes in a few seconds into a solid crystalline mass. The manifestation of that force is also beautifully illustrated in the following in-

stance: If a tin plate be heated to a moderate temperature, and a drop of water be allowed to fall on its surface, and the plate be dipped for a few minutes into weak muriatic acid, it will be observed that the whole surface of the plate is affected, and that where the water fell it has assumed a most beautifully waved and irridescent surface. If this surface be examined under the microscope it will be found that under the influence of the vibrations generated by the cold fluid falling upon the heated plate, the mass of molecules have passed from their amorphous condition to that of a crystallized one. We all know this alteration in the tin-plate surface was particularly applied many years ago to produce variegated surfaces on our tea trays and other similar domestic vessels. It should also be stated that this effect was greatly enhanced by the skilful application of colored varnishes, which increased the value of the mercantile article. This discovery, which is due to an eminent chemist of the name of Prout, clearly proves, as those before cited, the power which matter has to assume a crystalline form. I cannot, however, refrain from adding the following instances, in which the mere vibration of particles of matter is sufficient to change amorphous bodies into crystalline ones. The first is that which often takes place in the iron used on railways. The most striking example is that of the iron links used to unite wagons where it is found that the fibrous tenacious link made of malleable iron is transformed into a crystallized brittle link by the constant vibration it is subjected to by railway traffic. Another example is that shown by the peculiar action exercised by intense cold on the molecular state of iron, as shown by the brittleness of the metal in Russia and other cold climates; this was the case in December, 1859, in England, when, as will be remembered with regret, many railway accidents occurred, owing to the rails becoming crystallized and brittle.

The power which molecules have to assume a crystalline form has recently been the study of M. F. Kulhmann, an eminent chemist of Lisle, and he has given to that force the name "crystallogenic." I shall endeavor to lay before you a short epitome of his researches, which are not only interesting in a scientific point of view, but also in consequence of the mode in which he has applied it in connexion with arts and manufactures; and those who take an especial interest in the matter will read with pleasure his researches in the *Comptes Rendus de l'Académie des Sciences de Paris.* M. Kulhmann, having mixed a certain class of substances which crystallized with facility, such as mannite, sulphate of zinc, iron, copper, with a thick solution of gum, or any other substances interfering with the free crystallization of these substances, and having spread the mixtures on glass, he found, by exposing such prepared plates to the atmosphere, that gradually the water would evaporate, leaving a dry mass, in which could be observed most beautiful arborizations. Each of the solutions will produce a well defined design which is not always identical, although operating under the same circumstances. Still they assume very similar forms, being in some instances that of stars, and in others that of leaves and wreaths. These modifications are obtained by the

strength of the solution, the nature of the salt, and the mode of preparation. Kulhmann further observed, that if amorphous substances, such as magnesia and sesquioxide of iron, or chromium, be mixed with bodies susceptible of crystallization, and these added to a gummy fluid, the amorphous particles are drawn into the crystallizing substances and follow the outlines; and if these are produced on surfaces, such as glass or porcelain, and heat applied, the gummy matter will be destroyed or volatilized, and the crystalline medium and the amorphous substances become incorporated and fixed in the porcelain, reproducing on its surface a crystallogenic design. These researches which I have the pleasure to lay before you will show you the probability of carrying out these results to a satisfactory issue. Of course, the glass or porcelain manufacturer will easily understand that he will have to use borax or phosphate of soda or other flux, as a crystallizing medium, if he wants to produce in his art the results I have stated. M. Kulhmann has applied his crystallogenic process with great success to photography, and also to the art of engraving metals. As the latter may have some interest, I will give you an outline of his process. It consists in producing a crystallogenic design on the surface of an iron or copper plate, and then applying on the so prepared surface—say a sheet of lead or copper—and submitting them to high pressure when the design would be impressed upon the plate. The embossed plates, by being placed in a prepared solution, and in connexion with a galvanic current, will easily give birth to a *fac-simile* in relief, which can be used as a printing surface. It is with pleasure that I am able to state that though I part with these interesting researches for the present, I shall have the satisfaction of referring to them again in a subsequent part of this course of lectures, when I shall speak of some researches of this gentleman which have a more immediate bearing on the progress of science.

It has been for a long time a disputed question whether the stained windows we all admire in old cathedrals could be restored in such a way as to resume the brilliancy they had at the time they were placed there by the artists. At all events there is now no doubt that this can be effected by the process discovered by my eminent master, M. E. Chevreul, as is proved by the application of it in connexion with the restoration of stained windows existing in a well known church in Paris—that from which the tocsin of St. Bartholomew was sounded—"St. Germain des Près." The process devised by M. Chevreul is highly practical. It consists in removing the stained glass from the windows, and dipping it for several days, first, in a weak solution of carbonate of soda of a specific gravity of 1·068, then washing it, and dipping it for several hours in a solution of muriatic acid of a specific gravity of 1·080. On the glass being washed and dried, it will be found as brilliant and beautiful as when it came from the hand of the manufacturer. M. Chevreul has found that the dim and dirty appearance which stained glass assumes by time is due, especially in large towns, to the various products of smoke being first condensed on the glass by fog and rain, and then becoming oxydized they act

as a cement to various mineral matters, such as chalk, gypsum, oxide of iron, &c., which help to impoverish the transparency of the glass. The alkali acts upon the organic matter and dissolves it, while the muriatic acid removes the minerals. The durability of glass placed in our monuments is extraordinary, when we bear in mind the curious results published some years since by the eminent chemist, Pelouze, who observed that when window, bottle, and other varieties of glass were reduced to a fine powder, and mixed with water, they were soon acted on, yielding a large quantity of silicate of soda to that fluid, amounting in several cases to eight or ten per cent. in cold water, and even to thirty-six per cent. when the finely pulverized glass was boiled in water; and that, in many cases, it was a definite compound which was dissolved from the glass, namely, a silicate of soda, composed of three equivalents of silica and two equivalents of soda. M. Pelouze explains the extraordinary difference in the effect which water produces on glass when in large masses of plates, as compared with its influence on the same substance when reduced into a fine state of powder, by assuming that, in the first instance, water does not act because it seldom remains sufficiently long in contact with the glass to act upon the elements which compose it; while, in the second case, there exist numerous points of contact between the fluid and the solid body, thus facilitating the action of the fluid on the solid material. I am inclined to think that the peculiar molecular condition the surface of glass assumes, when manufactured in plates or otherwise, must exercise a great influence on the property which glass has to resist the action of water. If it were not so, how could be explained the limited action which watery fields, such as wine, cause upon the interior surface of a bottle, though they remain in contact for many years? I can conceive glass assuming a peculiar surface by the pressure of the atmosphere, thereby producing a homogeneous one susceptible of resisting the action of water. A similar instance occurs in the case of polished steel, or of the rolled surface of wrought iron, or the skin of cast iron, which resist the chemical action of either air or acids in a far greater degree than does the interior of the substances which compose those metallic bodies.

Whilst dwelling upon old materials, you will allow me to give you an outline of a process devised by M. Stahl, for the preservation of antidiluvian fossils. We are aware how interesting it is to preserve relics of past ages, giving us some of the conditions of the world at various periods. Those relics are exceedingly fragile, and after many clumsy attempts M. Stahl arrived at his discovery. If the fossil is compact and comparatively firm, it is saturated by means of a brush with melted spermaceti, but if it is friable, it is necessary to employ a melted mass composed of four parts of spermaceti and one of colophany resin, which in cooling gives great solidity to the mass of the fossil.

I would, in conclusion, draw the special attention of all artists who take an interest in decorative art to the interesting papers published recently by M. Onfroy on the one hand, and M. Wiel, of Paris, on

the other; the first being in the *Technologiste* of last year, the latter in the *Annales de Chimie et de Physique*, on their respective methods for covering a metal with another more valuable by its properties or precious by its qualities. These methods have a special reference to cast iron or wrought iron. In Paris, these processes, which may be regarded as not only ornamental but useful, have been applied with great success. Thus, for example, instead of the dirty, pitchy black lamp-posts which ornament our English towns, there can be seen in Paris elegant well designed bronze-like posts, which are pleasing to the eye. The same can be said of the fountains on the Boulevard Sabastopool, the Place de la Concorde, and many other public promenades in Paris, which excite the admiration of foreigners visiting that city.

(To be continued.)

On the Tenacity of some Fibrous Substances. By Professor W. J. Macquorn Rankine, C.E., L.L.D., &c.

Read before the Institution of Engineers in Scotland.

From the London Mechanics' Magazine, January, 1866.

In order to compare the tenacity of a substance with its heaviness, the load required to tear a given bar, strip, or cord asunder is to be multiplied by the length of so much of the same bar, strip, or cord as weighs an unit of load; the product being the tenacity of the material expressed in units of its own length. The following examples are taken from ordinary tables of the heaviness and tenacity of materials:

Material.	Dimensions.	Tearing load lbs.	Length in 1 lb. weight, in feet.	Tenacity in feet of the Material.
Cast steel bar,	1 in. × 1 in.	130,000	0·297	38,610
Charcoal iron wire,	area 1 sq. in.	100,000	0·3	30,000
Iron wire rope,	girth 1·27 in.	4,480	0·6	26,880
Iron bar, strong,	1 in. × 1 in.	60,000	0·3	18,000
Boiler plate, strong,	area 1 sq. in.	50,000	0·3	15,000
Teak wood,	1 in. × 1 in.	15,000	3·0	45,000
Deal,	1 in. × 1 in.	12,000	4·0	48,000
Hempen rope, hawser-laid,	girth 1 in.	1,050	26 0	27,300
Hempen rope, cable-laid,	girth 10 ins.	67,200	0·279	18,750

It would be easy to multiply examples such as the preceding. If the same method be applied to the weights and tearing loads of canvas, as given in Mr. Carmichael's paper on that subject, the following are the results:

	Royal Navy Canvas. Mean of Nos. 1, 2, 3, 4, 5, 6.	Mean of Nos. 7 and 8.
Tenacity of warp in lineal feet of canvas,	21,552	27,200
Tenacity of weft in lineal feet of canvas,	30,788	32,000
Mean tenacity of the flaxen yarn in lineal feet of itself, being the sum of the tenacities of the warp and weft,	52,340	59,200

These results show the least strength that is allowed to pass the test. Since reading Mr. Carmichael's paper, and making the foregoing calculations, I have made some experiments on the tenacity of flaxen thread and silken thread, of which the following are the results: The flaxen thread was unbleached, and measured 15,833 feet to the pound weight. Its tenacity was not uniform in different parts; and, as in the practical use of any material, the least strength alone is to be relied on, I ascertained carefully the breaking load of the weakest parts of thread, which was 6 lbs. Hence the tenacity of that thread, in feet of itself, was $15{,}833 \times 6 = 95{,}000$ feet. The silken thread was of two sizes, measuring, respectively, 9417 feet, and 19,950 feet to the pound. The tenacity of each specimen was sensibly quite uniform at different points. The breaking load of the thicker specimen was 12 lbs.; that of the thinner specimen, 6 lbs. Hence their respective tenacities, in feet of themselves, are as follows: Thicker specimen, $9417 \times 12 = 113{,}000$ feet; thinner specimen, $19{,}950 \times 6 = 119{,}700$ feet; the latter specimen thus proving to be three times stronger for its weight than cast steel.

In these experiments the length of one pound of the thread has been ascertained to the precision of about 1 per cent., and the breaking load to that of 3 or 4 per cent. It is probable that silk is the most tenacious for its weight of all known substances; and when, together with that fact, we take into account that its specific gravity is almost exactly that of water, it would seem, from a purely mechanical point of view, as if silk were the most suitable of all substances to give strength to submarine telegraph cables. But, unfortunately, when we consider the question from a financial point of view, it turns out that the price of silk is so high as to make its use in telegraph cables quite impracticable. Knowing that silk fibre is of the same heaviness with water, so that a prism a foot long, and an inch square, weighs 0·433 lb., it is easily computed that the tenacities of the two specimens in pounds on the square inch are as follows: Thicker, 49,000, very nearly; thinner, 51,900, or equal to the strongest plate.

I have also made a few experiments in order to determine the extensibility of silken thread; but the complexity of the phenomena which take place when that material is stretched have hitherto prevented my obtaining precise results. Even a small load produces a stretching which gradually increases with time, and which also gradually disappears after the load has been taken off. A load of $5\frac{1}{2}$ lbs. put upon a thread of the thicker kind, whose original length was 52·78 inches, produced a total extension of 3·56 inches, of which between 1·5 inch and 1·6 inch was *set*, continuing when the load was taken off, but gradually diminishing afterwards; while the remaining inch, or thereabouts, was elastic strain. About half of the set, viz: ·75 or ·8, had disappeared two hours after the load was taken off; the remainder continued to exist after the load had been off eight hours. The extension, with a given load, was on an average about 0·10 inch less when the load was increasing than when it was diminishing, showing the effect of what Professor William Thomson has called "molecular

friction." The results of the experiments correspond, on the whole, approximately with the following value: Modulus of elasticity of silk fibre, 3,000,000 feet = 1,300,000 lbs. on the square inch. If we take the proof load, or greatest safe load, at one-third of the breaking load, the modulus of resilience or power of bearing shocks, which is a third proportional to the modulus of elasticity and the proof strength, is found to be as follows, for the thicker specimens of silken thread: 473 feet, (that is, 473 foot-pounds for a prism weighing 2 lbs.,) corresponding to 205 foot-pounds for a prism 2 feet × 1 inch × 1 inch. The resilience of a tie-bar 2 feet long, and 1 inch square, has the following values for some other substances: Very strong tough steel, 60 foot-pounds; strong hard steel, 46; soft steel, 31; good iron wire, 36; good bar iron, 14; strong plate iron, 12; strong tough cast iron, 4. Occasions may arise when it is necessary to have cordage of the least possible weight for a given strength or for a given resilience, without regard to expense; and then, without doubt, the best material is silk.

The Cohesive Force of Red Sealing Wax.

From the London Mechanics' Magazine, January, 1866.

The cohesive force of the best red sealing wax has been proved to be equal to 1500 lbs. per square inch, and that of the black sealing wax rather more than 1000 lbs. to the square inch; the deficiency in the latter is attributed to the diminished quantity of lac used in the composition. The cohesive force of solid glue was found to be 4000 lbs. per square inch, that of cast iron is 25,000 lbs.

On the Properties of Parkesine, and its Application to the Arts and Manufactures. By ALEX. PARKES, Esq., of Birmingham.

From the London Journal of the Society of Arts, No. 683.

In introducing to this meeting the subject of Parkesine, the author wishes to explain the reasons that led him to the production of this substance.

For more than twenty years the author entertained the idea that a new material might be introduced into the arts and manufactures, and, in fact, was much required; he succeeded in producing a substance partaking, in a large degree, of the properties of ivory, tortoise-shell, horn, hard wood, india rubber, gutta percha, &c., and which will, he believes, to a considerable extent, replace such materials, being capable of being worked with the same facility as metals and wood. This material was first introduced under the name of parkesine, (so called after its inventor,) in the Exhibition of 1862, in its rough state, and manufactured into a variety of articles in general use; it then excited the greatest attention, and received a prize medal, Class IV., 1112.

Parkesine is made from pyroxyline and oil, alone or in combination

with other substances; the various degrees of hardness or flexibility are obtained in the easiest and most expeditious manner by varying the proportions of pyroxyline, oil, and other ingredients.

The pyroxyline, used as the base in the manufacture, can be made from any vegetable fibre, or fibre-producing grasses, starch, &c., but preferably of waste from cotton and flax mills, old rags, paper makers' half stuff, or any fibrous waste material capable of being reduced into a soluble condition by the action of acids. To subdue the inflammable nature of this compound, the inventor has introduced several substances, such as iodide of cadmium, tungstate of soda, gelatine, chloride of zinc, several carbonates, sulphates, phosphates, and other substances.

The oils employed are some of the vegetable and some of the animal kingdom; they may be used alone or combined, either in their normal condition, or changed by a solidifying agent, chloride of sulphur being preferred, which has the remarkable property of completely solidifying the oils almost instantaneously; but the chemical combination can be modified according to the per centages of the chloride of sulphur employed, which may be varied to meet the exigencies of commerce. These solidified oils, although unchanged by ordinary reagents, are readily soluble in the author's solvents of pyroxyline, by which means the two ingredients are combined to form one of the descriptions of parkesine.

The inventor, after much research, labor, and investigation, observed that the solid residue left on the evaporation of the solvent of photographic collodion produced a hard, horny, elastic, and water-proof substance. This led him to employ, in all his experiments, pyroxyline, xylodin, or some collateral matter, as his base for future operations. By the word pyroxyline, the author wishes to be understood a less explosive preparation than the more highly converted compound "gun cotton," and his constant aim has been to apply to peaceful industrial purposes a material hitherto only used for military, blasting, and photographic purposes. The solutions of collodion known at the time of his first patent, in October, 1855, were practically unsuited to carry out the manufacture in solid masses and other large forms. This necessitated a new series of experiments, to discover a more economical mode of production, and he found that, by improving the manufacture of pyroxyline, and using different solvents, considerable success was attained. As an illustration, to show the impracticability of using collodion for the manufacture of solid articles, we have here a bottle of ordinary collodion, which is submitted to your notice. This is a solution of pyroxyline in the well known solvents, ether and alcohol, and when you are told that, in one pint of these mixed solvents there is only one-third of an ounce of solid material, and the whole of this pint of solvents must be evaporated to obtain this small quantity of hard substance, you will readily conceive that the cost of production would be much too high for large commercial purposes. The cost of 1 lb. of the mixed solvents would be 2s. 6d., the pyroxyline being 10s. per pound, and as 1 lb. of pyroxyline would require 48 lbs. of solvent to make photographic collodion, there will be a total cost of 130s. per

pound for the solid material which could be obtained from the evaporation of such solvents. The small specimen of pyroxyline now exhibited is the exact weight of that contained in the bottle, whereas, by employing the same quantity of the author's patented solvents, this large bulk of unconverted cotton, which, for the sake of safety, represents a similar bulk of pyroxyline, can be dissolved sufficiently for the manufacture of parkesine.

The author commenced his investigations in face of the above-named difficulties, and endeavored, by more economical methods of manufacturing the pyroxyline or other similar compounds, and by the use of improved and less costly solvents, to produce a new and cheap material. This, after many years of labor and thousands of experimental trials, he has succeeded in doing, and at the present time almost any quantity may be made per day, (many tons—simply depending upon the apparatus,) at a cost of less than 1s. per pound and upwards, according to the quality required.

The two specimens shown illustrate the great difference between the two productions. The small piece is made from the collodion of commerce, at a cost of 130s. per pound; and the sheet is the result of that made from the present mode of manufacture, at a cost of less than 1s. per pound. This will at once establish in your minds the practical value of the invention.

Having then satisfied himself as to the possibility of producing the material at such a price as would allow of its application in the arts, his next step was, by the combination of various substances, to counteract the inflammability of the material—to produce various colors—and to modify its hardness, toughness, and elasticity; and, although from the above statements the object sought to be obtained may appear exceedingly simple, it nevertheless necessitated an enormous amount of application to arrive at the knowledge which has enabled him to produce the specimens which are now laid before you.

One of the greatest difficulties in the earlier stage of his experiments was caused by the excessive contractile properties of the dissolved pyroxyline, as the piece now produced, as compared with the comparatively large bottle, will clearly exemplify, being the whole of the solid residue contained in 35 cubic inches of collodion; in fact, if a stiff solution of pyroxyline were made, such as would not flow from a bottle, still such a preparation would contract to from ten to fifteen times its volume, whilst in the present workings only from one-fourth to one-fifth of a pound of solvent is used to one pound of pyroxyline; consequently the contraction is reduced in proportion to the solvents used.

The author had long to contend against the adverse opinions of many, that his efforts to introduce such an article for the general purposes of manufacture, from such expensive materials, appeared hopeless; and even since specimens were shown at the Exhibition of 1862, much discouragement has been thrown in the way of the progress of the invention by many who had conceived the idea that it would be impossible to produce the material at a price that would render it

valuable for general application; the inventor feels proud that he has been enabled to surmount these obstacles in so far establishing a new manufacture which—by the intelligence of practical minds, which he trusts will be devoted to its further development—will, he ventures to hope, eventually become one of considerable commercial importance.

The innumerable trials and investigations required, involved no less than twelve years labor and expenditure of many thousand pounds, before the material could be proved to be really of commercial importance; and although this may appear a long time to pursue one object, the author wishes to explain that time itself has been of the utmost importance in developing this manufacture, as it has enabled him to test the effect of time on the material, and also of atmospheric changes, and many other influences; this has proved of great value in arriving at his present knowledge of the material. Although he has been much engaged in other important business he was determined not to relinquish the manufacture of parkesine until the truth of what he stated at the Exhibition, in 1862—that the material could be produced in some of its qualities at 1s. per pound—was proved, and this he has satisfactorily established by twelve months practical working. One of the means which enabled him to produce parkesine at a cheap rate, is the employment of waste cotton, in the shape of rags or otherwise, which are procurable at an exceedingly low price, and also the use of improved solvents, and the means of recovering them by special machinery; also the being able to dissolve the pyroxyline in a wet state, thus avoiding the time and great space and risk of drying, which was the practice until recent important improvements enabled him to accomplish this most important desideratum.

When it is necessary or desirable to increase the flexibility or elasticity of preparations of pyroxyline, the author combines therewith oil, solidified or partly solidified by the action of chloride of sulphur, a reaction discovered by him some twenty years ago, when engaged in investigations relative to the cold process of vulcanizing india rubber, patented by him about that time. The chloride of sulphur is dissolved into bisulphide of carbon or mineral naphtha, the proportion suitable for the purpose being from 10 to 15 per cent. of chloride of sulphur to the cotton-seed, castor, or other oils. This will be found (as will be exhibited to you by experiment) to be of a solid or semi-solid consistence, according as more or less of the chloride of sulphur is used, so that the physical condition of preparations of pyroxyline may be considerably modified to suit special application by the use of gums, resins, paraffin, stearine, tar, glycerine, and other substances combined therewith.

The author would observe that the result of using a large proportion of the chloride of sulphur is to solidify the oil, (even to a jet-like mass,) but it is preferable to use about 15 per cent. to produce a tough elastic substance. He wishes it to be observed, generally, that in proportion as the oils predominate, so is the elasticity of the materials regulated.

Another important improvement in the manufacture of parkesine

is the employment of camphor, which exercises an advantageous influence on the dissolved pyroxyline, and renders it possible to make sheets, &c., with greater facility and more uniform texture, as it controls the contractile properties of the dissolved pyroxyline; camphor is used in varying proportions according to requirement, from 2 per cent. to 20 per cent. Another of the author's improvements for the like object consists in the use of gelatine dissolved in glacial acetic acid.

The author believes he was the first to employ colors in the dissolved pyroxyline. The solvents used in the manufacture of parkesine are also good solvents of the aniline colors; this gives the great advantage of producing the most beautiful colors in a transparent substance, as well as in opaque or solid masses, as the specimens will show; and when these colored articles are carved, the most exquisite effects are produced, imitating amber, malachite, and many other natural substances; moreover, as the material can be moulded by pressure, the most beautiful works of art can be copied at a very small cost. For many large and cheap applications, as much as 60 per cent. of pigments, sawdust, or cork-dust can be introduced with advantage, and thus is produced a beautiful and solid substance, very strong, which can be moulded and turned in a lathe or rolled into sheets, the cost, owing to these admixtures, being exceedingly low.

In all large manufactures the most important point to be considered is the production of raw material, which, in many cases, fails in quality and supply. The substances the author employs in the manufacture of parkesine are procurable in any quantity, and having a perfect control in the manipulation of the materials used, he can always ensure a regularity in the various qualities required, thus placing at the command of the artisan a material to be had at all times of a uniform standard quality, which he conceives to be no slight boon to the manufacturer.

There is another important feature in the economy of this material—no loss in manufacture is experienced, every particle, scrap, or dust can be reworked, and the most beautiful effect produced. Specimens will show the effect of some of the waste scraps remanufactured, and it will be readily seen that by careful admixture of colors very pleasing results may be obtained. This is another important advantage over other materials, such as ivory, tortoise-shell, india rubber, vulcanite, gutta percha, &c., with which this substance is calculated to compete.

The difficulties in manufacturing this material on a commercial scale were at first very great, as before explained, but by steadily persevering, the manufacture is now rendered very simple and rapid. From five to ten tons of parkesine sheets can now be produced in less time than one ton of india rubber. Sheets of large size and of any thickness, solid blocks, tubing, or other forms, can be made in a few minutes, and from the cheapness and unlimited supply of the raw materials employed, the price of parkesine will, it is believed, be much less than that of india rubber, ebonite, gutta percha, ivory, tortoise-shell, and many other materials.

Many specimens on the table have been produced from materials made ten years ago, in which no change or decomposition has taken place; the substance is not affected by sea-water, in which it has been immersed for a period of four years without the least deterioration, nor is it softened by heat like gutta percha, and, therefore, it is not likely to be affected by the heat of tropical climates.

It can be made transparent, or in any colors, variegated to imitate tortoise-shell, marble, malachite, hard or flexible; can be moulded, shaped, by dies or pressure, turned in a lathe, worked into screws, cut with a saw, planed, carved, engraved, rolled or pressed into sheets, as all the articles in the case before you will clearly show; it is very agreeable to the touch, and is susceptible of the highest polish; it can be inlaid with metals without any injurious effect upon them after years of exposure; it is also invaluable as a water-proofing agent, and can be used as a varnish for a variety of purposes, and as a non-oxidizing agent for the protection of iron ships, &c.

The various stages of manufacture are fully illustrated by the variety of specimens now before you, from the unprepared cotton waste to the ultimate conversion into the finished articles.

Perhaps one of the most interesting facts in connexion with this new manufacture is the employment of nitro-benzole, or aniline, by which improvement very great facilities are obtained in dissolving pyroxyline, and as these materials are also solvents of india rubber and gutta percha, a combination of these substances may be readily obtained which will be valuable for many purposes. A specimen of this combination is on the table.

The applications of this material to manufactures appear almost unlimited, for it will be available for spinners' rolls and bosses, for pressing rolls in dyeing and printing works, embossing rolls, knife handles, combs, brush backs, shoe soles, floor-cloth, whips, walking sticks, umbrella and parasol handles, buttons, brooches, buckles, pierced and inlaid work, book-binding, tubes, chemical taps and pipes, photographic baths, battery cells, philosophical instruments, waterproof fabrics, sheets, and other articles for surgical purposes, and for works of art in general.

There is one application of the parkesine which, as far as experiments have gone, promises to be of great importance, viz: insulating telegraph wires. It will be at once evident, from the nature of the ingredients used, that by simple mechanical and chemical processes, perfect freedom from impurities or foreign ingredients can be attained—a most important property in a material which it is intended to employ for electrical and insulating purposes. The difficulty of producing a pure and homogeneous article, has, there is reason to believe, resulted in the total failure of some thousands of miles of submarine cables and underground wires. Parkesine is placed upon the wire by being forced through a die in successive coatings with the same facility as gutta percha, and the author believes it to be far less liable to faults than india rubber.

A few specimens of the application of the material for electrical and

telegraphic purposes are exhibited. It is, however, deemed advisable to state, that extensive experiments have been made under the direction of Mr. Owen Rowland, (electrician to the late Joint Committee of the Board of Trade and the Atlantic Telegraph Company, appointed to inquire into the construction of submarine telegraph cables, &c.,) with the view of ascertaining to the fullest extent the electrical properties and applicability of the material for the above important purposes. The results of these experiments leave no reason to doubt that, on the completion of the necessary machinery, a most excellent and efficient insulator will be produced, (and, indeed, it has already been produced, even by imperfect and inadequate machinery,) possessing all the requirements of insulation.

Short specimens of insulated wire (made by hand) in this substance for underground and ariel lines are exhibited, the latter in the form of a multiple cable, according to the valuable patent of Professor Wheatstone, containing an insulated sustaining iron wire, and seventy-nine insulated conducting copper wires, both insulation and protecting envelope being effected by parkesine, which, possessing great strength and flexibility, and being a non-oxidizing material, is extremely well adapted for the latter purpose. This cable is believed to be capable of bearing its own weight in air for a distance of upwards of one mile.

In its hard and solid form, by virtue of its high insulating and non-oxidizing properties, this material is peculiarly well adapted for electrical instruments, terminal boards, testing boxes, batteries, insulators for poles, and many other philosophical purposes, and the advantages to be derived from the employment of a material which remains free from oxidation under all conditions, will be duly appreciated by electricians and experimentalists in their daily operations and investigations. Its tensile strength is considerably above that of either gutta percha, india rubber, or any other insulating material. Joints can be made with the greatest facility and perfection.

In the following instruments on the insulating power of parkesine as compared with various other materials, the greatest care was taken to secure a correct and reliable result. The temperature was constantly maintained at 61°; the pieces were thoroughly dried, to avoid surface conduction; the same surface length of each made to rest on the metallic stand in contact with earth; the blotting paper between the *piece* and the metal kept saturated with water, so as to ensure complete surface contact; the leakage of the instrument itself frequently ascertained; the full tension at the commencement of each test recorded as well as the exact time. The tests, in some instances, were repeated several times with uniform results.

Experiments made at Hackney Wick, on the 29th August, 1865, on the loss of insulation on the lengths of variously coated copper wires, &c.; instrument employed, a Peltier electrometer. Full tension, 40; temperature, 61° Fahr.

Parkesine,	5° in 1′ 45″
Plain gutta percha,	5° " 0′ 37″
Gutta percha and Chatterton's compound,	5° " 1′ 8″
Plain gutta percha covered with parkesine,	5° " 1′ 4″
India rubber, (masticated,)	5° " 1′ 15″
India rubber, (virgin,)	5° " 0′ 30″
Ebonite disk,	5° " 2′ 10″
Parkesine disk,	5° " 2′ 35″

The author has been furnished by Mr. Owen Rowland with the result of a further series of experiments made recently by him on the insulating properties of the material. These tests were made upon slabs and sheets of various qualities, hardness, and flexibility. Specimens are exhibited.

The value of the insulating properties of each piece in comparison with ebonite is shown in the following table:

	Leakage.		Time.
No. 1 specimen,	11·5°	in	1080″
" 2 "	11·5°	"	510″
" 3 "	11·5°	"	180″
" 4 "	11·5°	"	360″
" 5 "	11·5°	"	210″
" 6 "	11·5°	"	185″
" 7 "	11·5°	"	212″
" 8 "	11·5°	"	509″
" 9 "	11·5°	"	25″
" 10 "	11·5°	"	2046″
" 11 Prepared oil or base of Parkesine.	11·5°	"	1930″
" 12 Ebonite,	11·5°	"	1050″

The third column shows the time occupied by the needle of the electrometer in falling from the maximum tension of the electric charge to one-half tension thereof, or from 50° to 38·5°.

It is satisfactorily proved that the more perfect the means adopted for rendering the material free from impurities, the more its efficiency for insulating purposes increases.

(To be continued.)

On the Flow through Apertures of Solid Bodies.

From the London Practical Mechanic's Journal, February, 1866.

In the preceding number of this Journal a review was given of the part for July, 1865, of the *Annales du Conservatoire Imperial des Arts et Métiers*, in which prominence was chiefly assigned to a memoir by M. Tresca on "The Flow (*écoulement*) through Apertures of Solid Bodies." These experimental investigations have done science so important a benefit by demonstrating as laws what have hitherto been more or less hypothetical, that the writer has deemed it expedient to place on record, in English technical literature, a *résumé* of the principal experiments upon which the conclusions hereafter given are based.

The memoir was presented to the Academy of Sciences on the 7th of November, during its session of 1864. It originally contained the first part of the investigations by M. Tresca on the flow of solid bodies, and which were completed June 12, 1865, being the subject matter of a report by General Morin in the name of a commission composed of MM. Pouillet, Piobert, Duhamel, and Morin—the first investigations being immediately followed by fresh researches on the same subject.

The memoir presented to the Academy has the following for its objects:

1. To show by the results of numerous experiments that solid bodies, when a pressure sufficiently intense is exerted upon them, flow in a manner similar to that of liquids. 2. To lay down the theory of this flow, and to point out the most important deductions that may be made to facilitate the study of the molecular motions, which are produced by the action of mechanical force on matter.

The same phenomena are proved for the soft as for the hard metals, for plastic substances, such as blocks of wax, for pulverulent matter, for granulated materials, such as musket shot, and in a manner only less complete than that for liquids themselves.

The newly discovered analogy which is found to hold alike in all bodies, in their varied conditions, has enabled some light to be thrown on the principles of the flow of liquids, as well as upon their *lateral attraction*, which these experiments on the flow of solid bodies determine, under a variety of circumstances.

This investigation has not been undertaken as a sequel to preconceived ideas, and as a point that it had been proposed ultimately to reach; neither is it presented as the mere consequence of varied experiments obtained in the first place among complex circumstances, so as to render many observations liable to be recalled as erroneous, but such that the laws of the phenomena themselves can be studied with facility.

Of the numerous experiments that have been made, the writer limits himself to mention three, which suffice to make known their character, and these he regards as fundamental. An example of each kind forms the head of each of the following citations of the experiments.

It is not desired to at once decide these as general consequences, without again returning to the inquiry concerning the flow of solid bodies, and a future opportunity is therefore reserved to review the circumstances in detail, and to examine the numerical data to be derived.

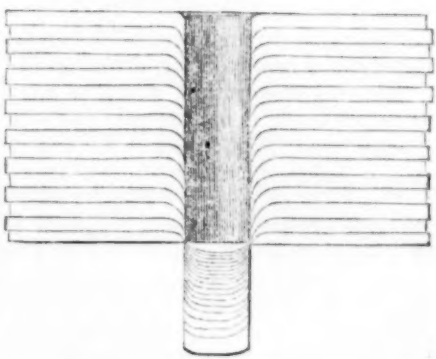
One of the experiments relates to the punching of metals; the second to the crushing of a cylinder composed of superimposed plates; the third to the simultaneous flow of a cylindric block of metal over its lateral surface and through a central orifice. It is, therefore, seen from the preceding statements, that there are three distinct types of experiments bearing, in their different aspects, upon the transmission of pressure into or through solid bodies, so as to ascertain whether the pressure does not reach beyond intermediate portions.

Experiment made on the 22d of April, 1864, upon the punching of a rectangular block composed of sixteen plates of lead.—The plates were square and $0^m{\cdot}120 = 4{\cdot}727$ inches in length of sides, the thickness being 4 millimetres = ·1572 inch, and the total thickness of the block of plates was $0^m{\cdot}064 = 2{\cdot}5198$ inches.

The plates were carefully placed one upon the other between two holding or guide plates, each of which was pierced with a hole in it of 20 millimetres = ·7860 inch diameter, and fitted with a punch sufficiently long to pass completely through the guide plates and blocks. The force of an hydrostatic press being applied to the extremity of the punch, this penetrated the lead block, the metal of which moved away (*chassé*) before the punch in the form of a cylinder of 20 millimetres = ·7860 inch diameter; but this extended cylinder had only a height or length of 31 millimetres = 1·129 inch, whilst the total depth of the hole was the total thickness of the series of superposed plates, viz: 2·5198 inches. (I must here premise, that in future in this memoir, I shall use the French term "débouchure" to express the portion or mass of metal that is punched out or extruded from the block under experiment, as there appears to be no word in the English language which so decidedly expresses the meaning which, in the present case, it is desired to convey. It is true we have the word "burr," a workshop term for the piece of metal punched from a plate, and even this, irregular and non-etymological as it must be from its origin, answering the purpose of the operative boiler-smith, is wholly unsuited for the present purpose.) This diminution of height had been before obtained in the punching of a solid block of lead of the same dimensions as the laminated block.

Accordingly, the débouchure, which should have been 64 millimetres = 2·5198 inches in height or depth, was in reality but 31 millimetres = 1·130 inch; the density of the metal not having, as might have been supposed, increased during the process of punching, the experiment tried with superposed plates ought, therefore, to decide the question of knowing how the elimination of half of the metal, which occupied beforehand the place filled so slowly by the punch, was produced.

Fig. 1.



This débouchure of the 22d April, Fig. 1, is indeed remarkable. On cutting it in half, and facing or smoothing over the cut faces, the fifteen lines showing the number of divisions of the primitive block were visible; but whilst the topmost plate and the three lowest plates *only* were represented in the débou-

chure in their original thickness, all the intermediate plates were represented with their original thickness considerably reduced, as will be seen by reference to the following table of measures taken on dividing off or separating the lower faces.

The elimination of the metal, then, took place horizontally throughout the intermediate parts of the block proper; then, without doubt, the resistance in that direction was less than that of all the layers or strata situated in front of the punch.

TABLE *of the Thicknesses of Plates Measured along the Axis of the Débouchure.*

Numberof Plates in the Débouchure.	Distances of the Lines of Joints to Extremity of Débouchure.		Thicknesses of Plates Measured along the Longitudinal Axis.	
	Millimetres.	Inches.	Millimetres.	Inches.
1	4·6	·1807	4·6	·1807
2	9·0	·3587	4·4	·1729
3	13·0	·5109	4·0	·1572
4	16·2	·6366	3·2	·1257
5	20·0	·7860	2·8	·110
6	20·8	·81764	1·8	·0708
7	22·0	·8616	1·2	·0471
8	22·7	·88911	0·7	·0275
9	23·4	·92962	0·7	·0275
10	23·9	·9347	0·5	·0196
11	24·2	·952	0·3	·0117
12	24·6	·967	0·4	·0157
13	24·8	·975	0·2	·0078
14	25·3	·995	0·5	·0198
15	26·9	1·057	1·6	·0628
16	31·3	1·230	4·4	·1729

The first consequence to be drawn from the foregoing is, that the vertical pressure exercised by the punch transmits itself laterally or horizontally through the solid block, and repels the material of the débouchure into it in the direction of least resistance.

But this observation, which is certainly one of the general results of actual work, is not the only one which can be drawn; there is found, besides, that distinctness of the concentricity of the couches or strata that are met with among circumstances more simple and better defined.

The lines of joint are slightly curved in that portion contiguous to the axis of the débouchure; and on carefully examining them by aid of a microscope, it is found that they touch the extreme diameter of the portion of the débouchure immediately above, each one of the portions of the plates thus forming a kind of capsule with very thin edges, enveloping on all sides those capsules situated immediately above it, whilst it itself is similarly enveloped by the capsules situated below in the order of primitive superposition.

This disposition of the strata in the débouchure has elsewhere its analogue in the pierced block.

Each one of the plates traversed through by the punch bends itself or yields in a curved form around the hole formed by the passage of the tool, being tapered off very fine at the parts bordering on the hole in such a manner as to be drawn out in an extremely thin tube, and so that a perfect division or lining is uniformly produced all through the punched hole by the tube primarily issuing from the superior or uppermost plate; which tube is successively caught into the substance of the next plate by the other tubes proceeding from it; and thus throughout the blocks the tubes, respectively, forming the elongations of each one of the primitive plates.

The plates, being imbedded one in the other, cannot be separated without fracture. Moreover, the same disposition of their fractures facilitates the verification of the summary indications about to be given.

The annexed Fig. 2 is given with the fractured or separated tubes which accompany it, and which belong, that is to say, which are broken off on the upper sides from plates 3 to 5, and on the under from plates 7 to 13, in the order that they occur in the block, the upper parts of these fractured tubes remaining adhering to the different plates.

Fig. 2.

On cutting through similar blocks, the cut being across the axis, there is also found all the lines of joint, and the tubular constitution appears with the completest evidence; also, that these (tubes) are preserved by the pressures transmitted by the adjoining strata, (*couches.*) Each one of the plates appears endowed with more perfect malleability, which permits it to laminate to the extremest thickness without being torn or fractured. This valuable property will be observed in nearly all the examples that will be cited.

Since then, there has been found in the débouchures of thick iron plates produced in the workshops of mechanical engineers the same lateral elimination and the same capsules.

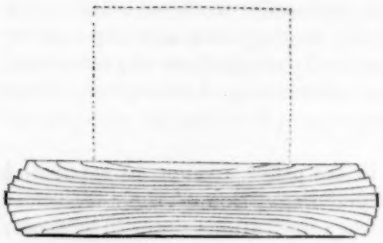
The first observations on the punching of lead are found, moreover, verified for a hard metal, such as iron, punched cold.

Experiment of June 3, 1864, *on the crushing of a cylindric block made up of twenty plates of lead.*—These twenty plates had together a thickness of $0^{m}{\cdot}063 = 2{\cdot}48$ inches, and a common diameter of $0^{m}{\cdot}060 = 2{\cdot}36$ inches.

This diameter had been produced to $0^{m}{\cdot}110 = 4{\cdot}39$ inches, by crushing, at the centre of the height, and to $0^{m}{\cdot}103 = 4{\cdot}05$ inches, and $0^{m}{\cdot}105 = 4{\cdot}134$ inches at the ends, the original height being thus

found reduced to $0^{m}\cdot108 = 4\cdot253$ inches. All the plates are not found to comport themselves in the same manner. The end (that is, the top and bottom plates, Fig. 3.,) are scarcely increased in diameter, whilst the edges of the intermediate plates are bent up all round, in a manner as to form with them the flat upper and lower faces of the crushed or compressed block.

Fig. 3.



The thin or shallow block (*galette*) thus formed being cut across the axis, it is found that the deformations were not identical for all the blocks. On the contrary, it was seen that the deformation was produced especially at the centre of the block, a flow from the axis to the circumference having taken place; and the lines of joint, which were at first parallel, formed by the compression a sort of saucer, very thin and spread out at the centre, and growing thicker towards the edges, which shows in what direction the displacement of the molecules took place.

Poncélet had long since pointed out how, resulting from the resistance due to friction, the expansion or thinning out of the base of a cylinder was prevented, in an investigation upon the more marked thinning or compression (*épanouissement*) which was produced in the central portions; but this retardation is in reality much greater than the exterior appearance would give reason to suppose, since the experiment actually shows that the original vertical wall (*paroi*) becomes folded into the plane of the base in a manner to increase the diameter of the primitive or original base. The lines of joints of the upper and lower plates after compression become curved to extreme edges, and the parts which were formerly vertical edges are now thinned out, and, as it were, run or flow into the planes of the upper side and base of the crushed cylinder. Thus each of the planes of the original joints is transformed alternately into a convex and concave surface.

This experiment is especially cited because the result produced justifies, in a prominent manner, the rather strange expression employed when speaking of *the flow of solids*, (*l'écoulement des solides.*)

This block of twenty plates had been compressed between two blocks of metal. One of these pieces was of cast iron, dressed by a file; and the impression (*thinning*) is apparent on the surface of contact of that piece, following the concentric couched disposition previously indicated. The other supporting piece was of malleable iron plate surfaced in a planing machine, the striated tool-marks being allowed to remain on it.

These striæ, all of which were parallel, formed so many little canals, which were almost microscopically small—three such canals, with their divisional boundries or ridges, being equal to a millimetre in breadth over all. They sufficed, however, to considerably facilitate the flow of

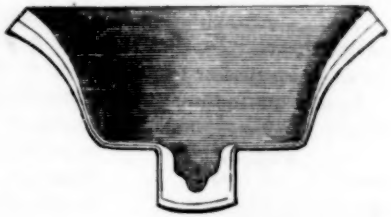
the crushed metal; moreover, the lines of joints, as they became successively impressed upon that surface, spread out in an *oval* in place of a *circle*, their normal form; and the circles of the *original* vertical wall of the cylinder, now having flowed over parallel to the surfaces of compression, these also become converted into oval forms, the major axis of which is situated parallel to the direction of the little canals. This last fact has been reproduced in a great number of experiments, and should be enough to distinctly indicate the marked fluidity of solid bodies when acted upon by great pressures.

Experiment of August 24, 1864, *on the simultaneous flow, at the edge and at the centre of a block formed of two plates of lead.*—Two plates, 3 millimetres = ·1179 inch in thickness, and 100 millimetres = 3·93 inches in diameter, were placed under a hammer. They rested upon a plate pierced at the centre by an orifice 20 millimetres = ·7860 inch in diameter, and there was placed upon the upper surface of the second plate a steel cylinder of 50 millimetres = 1·965 inch in diameter; which cylinder was formed with a sharp point at the centre of its upper end, so that when struck by the hammer the force of the blow might be evenly imparted to the whole of the surface of the plate immediatly below the cylinder.

The compression having been determined by ten successive blows of the hammer, the different pieces were lifted off, and it was found that the original thickness of the plates had been reduced to 2 millimetres = ·0786 inch, over the whole part comprised between the two faces of the pieces of metal over which the pressure had taken place. Throughout the whole of these parts of the plates, the two faces (upper and lower) remained flat, as well as the surface of the joint; but beyond this and at the centre the plates had undergone very considerable and remarkable modifications.

At the exterior (see Fig. 4) the plates became curved upwards in the form of a widely open tulip, their thickness gradually thinning down, as if the stream of matter that the force of the blows had extruded had, at the same instant, a thickness determined by that of the part compressed, the two thicknesses being found the same.

Fig. 4.



This very regular tulip-shaped cup of lead recalls, but under more distinct conditions, the beautiful acanthus-shaped leaves obtained by MM. Piobert, Morin, and Didion in their experiments on the stroke of leaden projectiles.

It is possible to determine the exact nature of the surfaces thus transformed, but it will suffice at present to assert that the transformation results geometrically from the gradual flow of metal of the cylindric ring comprised between the two points which exert the compression, as well as from the resistance that the ring thus extruded at

the same instant experiences, in consequence of its connexion with the neighboring molecules at once introduced into the thinned part of the plate.

At the centre the modifications are of the same order.

The portions of the plate squeezed through the central hole in the lower plate form a sort of hollow jet, (débouchure,) thick at the centre; and from this point the walls of the hollow débouchure diminish in thickness, in a manner similar to what has previously been shown for the outer extruded portions of the plates. The central flow of the metal would appear to have drawn together the middle parts of the plates, and to have transported them to the extremity of the jet.

This example proves very clearly that the vertical pressure between the two supports (upper and lower) is transmitted through the leaden block to the free parts at the centre opening of the bottom plate, and at the circumference of the two plates between which the pressure is exerted, and that this action has produced two jets or flowings of metal of different forms, but both possessing one common property—that the thickness of the walls in each case successively or gradually diminishes, and the original plane surfaces become changed into those of a curved form, approaching more or less the form of a cylinder, and representing the result of the two contrary actions; one of these depending on the fact of transmitted pressure, the other on the bending or cohesion of the particles of the material.

This circumstance, which appears paradoxical, it is difficult to otherwise explain, from the void or empty space in the central jet occurring precisely at the single point where the pressure which should be transmitted to the mass of lead is not counterbalanced by the resistance of an interior support. It is believed that the jet, in place of being cylindrical at the exterior, becomes contracted, so that the original thickness of the plates becomes much reduced. From this one analogy with the flow of liquids, it enables an analysis to be made of the principles which determine for all bodies the contraction (*vena contracta*) so long since observed in the flow of liquids.

The experiment which will presently be described, considered in its entirety, realizes the double flow which was simultaneously obtained through an orifice at the centre as well as one at the exterior.

It was made much more quickly, as the pressure was produced by means of an hydraulic press; but in order to vary as much as possible the mechanical elements of the question, it was thought preferable in this, the third list of experiments, to attract attention to one of the samples of material experimented upon, in which the compression and consequent flow was produced by means of hammer blows: both the experiment with the press and with the hammer furnished analogous results.

Fig. 5.

The influence of the ring or boundary outside the plates is completely shown in the sample experimented upon on the 20th August, 1864. See Fig. 5.

(To be continued.)

A New Process for Quickly and Economically Converting any Mass of Cast Iron into Steel. By M. Galy-Cazalat.

From the London Chemical News, No. 320.

The author passes superheated steam into the fused iron. In traversing the mass the steam is, of course, decomposed; the oxygen burns progressively the carbon and oxide of iron, while the hydrogen combines with and removes the sulphur, phosphorus, and other metalloids which render the steel brittle. When the color of flame at the top of the mass indicates a proper amount of decarburation the steel is run out. The author operates either in a cupola or a reverberatory furnace of his own construction, in which the waste heat from the furnace is utilized to produce the steam. There has always been a difficulty in knowing when to stop the decarburating current, the process often being carried too far; but to-day, says the author, common steel can always be regularly produced by completely decarburating the cast iron and then adding 10 per cent. of spathic cast iron, which restores to the iron the amount of carbon necessary to effect the conversion into steel. By a peculiar contrivance the author shuts off the current of superheated steam from the metal and passes it into the chimney, where it serves to increase the draft in the furnace, and thus leaves the steel in a state of tranquil fusion for about fifteen minutes, by which he gets a perfectly homogeneous mass. To remove bubbles in his castings he has a very ingenious device. A cannon, for example, being cast, while the metal is still hot and soft, he covers the mould hermetically with a sort of hat, from the top of which rises a pipe, in which is placed 6 or 10 grammes of a mixture 80 parts of saltpetre and 20 parts of charcoal. By opening a stop-cock the powder is allowed to fall on the metal, where it gets ignited, producing a large quantity of gas which exerts pressure on all parts of the casting, removing the bubbles and increasing the tenacity of the metal.

New Differential Anemometer. By E. Swann, F.C.S.

From the London Chemical News, No. 322.

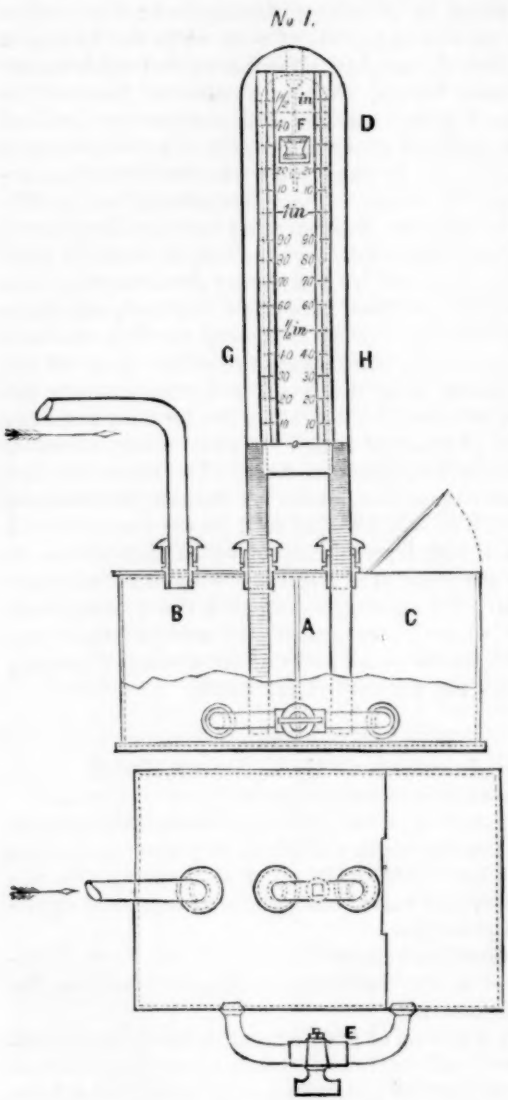
I beg to forward, for insertion in the *Chemical News*, a description of an instrument for measuring slight variations of pressure, trusting that the information may be of interest to many of your readers, not only on account of its practical value, but also as an ingenious application of a philosophical principle.

The instrument in question is in use at the London and North Western Works at Crewe, and is the invention of Mr. Ramsbottom, the company's mechanical engineer.

At these works Siemen's system of gas furnaces is being introduced for the manufacture of iron and steel, and as it has been found advisable to register the pressure of the gas, which only varies a few hundredths of an inch of water, an instrument of more than ordinary delicacy was required.

It occurred to Mr. Ramsbottom that an instrument having the requisite sensitiveness might be constructed on the differential principle

by means of a syphon tube, containing two fluids of different densities. As shown by the accompanying diagram, the instrument consists of an oblong box, divided, by the diaphragm (A), into two cisterns, one of which (B) is air-tight and fitted with a tube through which the pressure is applied, and the other (C) merely closed by a lid. The two cisterns are about half filled with water, and are connected by means of a glass syphon tube, the legs of which are equal in length. The ends of the tube pass through glands, and reach nearly to the bottom of the cisterns.



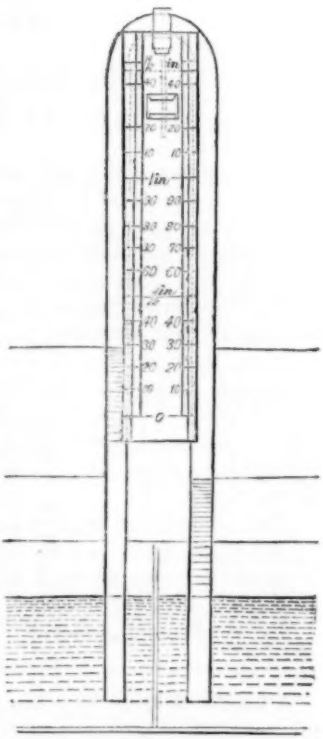
The upper half of the tube is filled with a fluid, such as benzole, mobile, insoluble in and of less specific gravity than water, the lower halves of the two legs being filled with the water, which may be tinged pink with cochineal. To prevent evaporation, the surface of the water in the cisterns is covered with a film of oil. Should, however, the level of the two cisterns be disturbed from any cause, it can be restored by means of the stop-cock (E) connecting the two cisterns.

In the instrument as constructed the lighter fluid is benzole, in which camphor has been dissolved in sufficient quantity to obtain a specific gravity equal to eight-tenths that of water, or a difference of one-fifth.

The scale, with which the instrument is fitted, is divided in this latter proportion, so that each one-tenth of an inch pressure, in inches of water column, is represented by five-tenths of an inch on the scale. These divisions being again subdivided, a variation of one-hundredth of an inch of water column may be clearly read.

A screwed wire, suspended from the bend of the tube by a brass clip, carries the scale, which can be moved by the milled nut (F), to adjust the zero of the scale to the points of contact of the two fluids.

No 2.



The action of the instrument is as follows: Any excess of pressure in the air-tight cistern (B) raises the level of the water in the leg (G) of the syphon tube, and causes a corresponding depression in the other leg (H), and the amount of variation between the two water-levels will be inversely proportional to the difference between the densities of the two fluids.

It will be seen that, assuming the difference of level in the two legs to be one inch, and, drawing lines across the figure at the two points, (see Fig. 2,) that the benzole in each leg above the higher level, being equal, is balanced, as is also the water below the lower level. There only remains, therefore, the inch of water on the one side against the inch of benzole on the other; consequently, the amount of pressure expressed in inches of water will be equal to the difference between the weight of the two columns, which difference in this case (one-fifth of an inch) is represented on the scale by a distance of one inch, thus giving a scale magnified five times.

I should be glad to hear of a suitable fluid of a density approaching nearer to that of water, as the less the difference between the two fluids, the larger the scale becomes.

It need hardly be pointed out that the instrument can also be used to indicate negative pressure, the action in the tube being merely reversed, and the reading taken from the opposite column, as in the case of a chimney draft.

Artificial Ivory.

From the London Journal of the Society of Arts, No. 680.

The *Mechanics' Magazine* says that the process by which the most successful imitation of natural ivory is obtained appears to consist in

dissolving either india rubber or gutta percha in chloroform, passing chlorine through the solution until it has acquired a light yellow tint, next washing well with alcohol, then adding, in fine powder, either sulphate of baryta, sulphate of lime, sulphate of lead, alumina, or chalk, in quantity proportioned to the desired density and tint, kneading well, and finally subjecting to heavy pressure. A very tough product, capable of taking a very high polish, is obtainable in this way.

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, March 21st, 1866.

The meeting was called to order with the President, William Sellers, in the chair.

The minutes of the last meeting were read and approved. The minutes of the Board of Managers were reported.

At the meeting of the Board of Managers, held on the 14th inst., donations to the library were received from the Royal Astronomical Society, the Statistical Society, and the Society of Arts, London, England; James Swaim, Esq., and, through him, from MM. Rudolph Kœnig, Arthur Cavalier, L. Breguet, J. Salleron, J. A. Deleuil, and Eugene Lacroix, Paris, France; the Canadian Historical Society, Montreal, Canada; the Water Commissioners, Detroit, Michigan; and William Sellers, Esq., the Executor of the Estate of William J. Duane, deceased, Prof. John F. Frazer, M. Carey Lea, Esq., H. P. M. Birkinbine, Esq., Dr. T. S. Kirkbride, and J. F. Houston, Esq, Philadelphia.

The Committee on the Library reported that they had organized by electing Mr. Pliny E. Chase Chairman, and appointing the first Monday evening of each month for their stated meetings. They also reported their minutes.

The report of the Resident Secretary was then read, as follows:

Secretary's Report.

A borax-yielding lake has been discovered in California, which promises to afford a large supply of that valuable salt. It is located near Clear Lake, 65 miles southwest of Suisun Bay, and 36 miles from the Pacific, in a region of country decidedly volcanic.

The borax lake is about 4000 feet long by 1800 wide at present, though there are indications that in former times its extent was much greater. Its present depth is 3 feet. The water contains a large per centage of borax, but what is of more importance, a solid bed of this substance, in crystalline condition, lines the bottom of the whole lake. This solid salt is taken out by means of movable coffer-dams, and is found to be remarkably pure.

During the dry season of 1865, 240 tons, at the rate of $2\frac{1}{2}$ tons per day, were removed, 40 tons of which were used in the California mint, and 200 tons were shipped to New York.

Very near this lake is a considerable deposit of sulphur, where solfatara action is still going on, and also a hot spring, charged with a very large per centage of borax and carbonate of ammonia.

Mechanics.—There have been presented this evening for examination the following new inventions and mechanical adaptations:

Lyon's National Lifter, or Portable Crane, so arranged that it may be readily run from place to place, and set up by one man, and yet capable of lifting at least 10 tons.

A pulley with cam wheel, so arranged as to clamp the rope and prevent it from running back if the hoisting end should be broken or suddenly abandoned. Invented by R. T. Knight of this city.

A gas regulator, in which the flow of gas to a series of burners is regulated under changing conditions of pressure and consumption, by means of a valve controlled by a gasometer floated upon mercury. Invented by John H. Cooper of this city.

An altiscope or telescope, so arranged by a combination of mirrors and lenses as to enable an observer to look over or around an opaque object. This instrument is invented by John Clark, Esq.

A new arrangement of bar vice, invented by Mr. Linus Yale, was then presented, and, at the request of the Secretary, described by Mr. Coleman Sellers, as follows:

Mr. President: At the request of Mr. Linus Yale, Jr., of Shelburn Falls, Mass., I would call your attention to a parallel jaw or bar vice. This tool he designed to obviate a difficulty existing in all ordinary vices, the jaws of which are moved by a screw, viz: the time lost in opening and closing the jaws by the tedious process of turning the screw. In some kinds of work, such, for instance, as the manufacture of locks, the case of the lock requires to be held edgeways, and then flatways. This necessitates the jaws being opened through considerable distance, and then closed as each change is made in the way of holding. Mr. Yale, in noticing his workmen at this kind of work, found that 12 per cent. of their time was spent in screwing and unscrewing the vice. The instrument which I now show to you has a nut and screw with the bar, as usual, but the nut is not always attached to the bed or stationary jaw of the vice. To this jaw, in the under part of the guide, is a rack with ratchet teeth. The nut is square, and has teeth on its under side, corresponding to the teeth in the rack. The nut, when screwed to the back end of the bar, rides up an inclined plane, which so elevates it above the rack, that its teeth cannot engage therein. In this position the movable jaw can be pushed back and forth, *i. e.* opened or closed rapidly by hand without turning the screw. Placing a piece of work in the vice, as, for instance, this piece of wood, about three-eighths of an inch thick, you perceive I can push the jaw quickly up to it, and then one turn of the screw draws down the nut into the rack teeth, and a part of a turn will secure the work as firmly as if screwed in an ordinary vice. The same amount of back turns of the screw release it, and then the jaws can be opened wide to receive the block edgeways. They are about three inches open now, and one turn, &c., will again fasten it. The vice can be

used as an ordinary vice, by drawing out the movable jaw to any required distance, and then screwing it all the way home. It will, within the range to which it was opened, act as if the nut was fast to the stationary jaw. The rack in this vice is not rigid. It has a spring back of it so arranged as to allow one-eighth inch end motion. This enables the workman, when filing to a template, to adjust his work to the template with a slight pressure of the jaws, the movable jaw being elastic as it were. See! I can pull it back about one-sixteenth of an inch, yet the work is held firm enough to adjust. Workmen will appreciate this; for they are aware that in a rigid vice the work must be either very fast or very loose.

The tool seems to me to be a very useful one, indeed, and I would move that it be referred to the Committee on Screws and Nuts, for their examination. *Carried.*

In the late reports of the Society for the Encouragement of National Industry, (French,) we notice one at some length on a plan for the use of liquefied ammonia, in place of water, as a means of utilizing heat force, as in the steam engine.

In this report the whole subject of such substitutes is discussed, and it is shown that their introduction is founded upon a false inference. Because a slight elevation of temperature produces a great increase in the elastic force, tension, or expansion of such bodies, it is supposed that by these means more work may be obtained from a given amount of heat than by the use of a substance which, like water and steam, suffers less expansion by an equal change of temperature. In this case, however, the fact is forgotton that these first-named bodies have a latent and specific heat corresponding to their property of dilation, so that, after all, a given *amount of heat* produces the same amount of work or mechanical effect, though the *temperatures* concerned may be very different; for, in the case of the liquefied gas, where a great elastic force is developed by a slight increase of temperature, a large amount of heat is required to produce that slight increase, being expended as latent and specific heat, while in the case of steam, though less elastic force is developed by the same rise in temperature, a less amount of heat is required to effect this change.

In the same publication we notice a good arrangement for a safety lamp, by which the removal of the protecting cylinder of wire gauze is made instantly to extinguish the light.

Chemistry.—At a late meeting of the London Pharmaceutical Society, Mr. Haselden read a paper, in which was suggested a new application of the very useful substance—glycerine. By mixing with a pound of softened gelatine an ounce and a half of glycerine, an elastic material may be formed of great efficiency in capping or sealing bottles.

At the same meeting a new adulteration of saffron was described, and its mode of detection pointed out, which was either by the use of the microscope or by soaking in water, when pollen granules will separate and sink from the mass, if the stamens of the saffron flower, (crocus sativa,) which constitute this adulteration, are present.

Kuhlman, who has given much time to the study of the coloration

of minerals, and their power of absorbing various organic substances, states that, if plaster of Paris, with enough water in it to give it the constitution $CaO, SO_3 + 2HO$, is steeped in a bath of hot pitch, it loses its two equivalents of water, which are replaced by a corresponding quantity of pitch, and that it then becomes very hard and susceptible of a polish, so that it would be available for the construction of many articles for ornament or use.

The subject of coppering and bronzing by the use of alkaline solutions is discussed at some length, in the *Annales de Chimie et de Phisique*, by M. F. Weil. The important points involved in the process seem to be that the presence of organic matter, such as glycerine, albumen, tartaric acid, and the like, prevents the precipitation of a metallic oxide from an alkaline solution, but that when a galvanic action is established between the article to be plated and a piece of zinc (both immersed in the alkaline bath) the metal is deposited with facility.

Deodorizing and Disinfecting.—Dr. J. H. Barker, summing up the results of many experiments, makes the following statement. The most efficient means in various cases are as follows:

1st. For the sick room, free ventilation.

2d. For rapid action, chlorine.

3d. For steady and continuous effect, ozone.

4th. Next to ozone, solid iodine.

5th. For decomposing fluids, tincture of iodine.

6th. For solids, powdered chloride or sulphate of zinc with sawdust, carbolic acid and sawdust, or lastly, wood ashes.

7th. For clothing, a heat of 212°.

8th. Anything which may be destroyed should be burned up.

Ozone.—The well known chemical writer, Frémy, says, in a late report to the Academy of Sciences, that the only certain test for the presence of ozone is the oxidation of a bright surface of silver, and that, by this test, the presence of ozone in the atmosphere has never been proved. The iodized starch paper is affected by a multitude of agents, always present in the atmosphere, and is therefore of no value in this respect.

M. Soret presents a note to the Academy on the density of ozone, which, from various indications, he calculates to be 1·658.

Deville, in a late note on the hydraulicity of magnesia, states that a piece of compact anhydrous magnesia, left under a water-tap for several months, became perfectly hard and transparent as alabaster.

Busts like marble may be made of equal parts of this anhydrous magnesia (which is obtained by treatment of the chloride derived from sea-water) and powdered marble, pressed in moulds, and then exposed for some time to the action of water.

A dolomite, rich in magnesia, calcined and ground, forms under water a stone of very remarkable hardness.

To preserve specimens without the use of alcohol, a writer in *Silliman's Journal* gives, as the result of many experiments, minute directions for the preparation of several solutions of rock-salt and nitre of gradually increasing strength, and for the successive soaking of the

specimens in these, by which means they are uniformly charged with the salts in question, and preserved in a most satisfactory manner.

We see, by an article of some extent, published in the above journal, that the process of sodium amalgamation, lately patented in England by Prof. Crooks, was patented some time before in this country by Henry Wurtz.

It is stated that metallic titanium has been manufactured in some quantity, at Birmingham, by reduction with sodium.

There were then exhibited, by the Secretary, some persistent soap bubbles, made from a mixture of oleate of soda and glycerine, prepared by Mr. James T. Shinn, according to the formula published in the *American Journal of Pharmacy*, March, 1866, page 99. These may be blown of a convenient size, 6 or 8 inches in diameter, and set upon wine glasses, and, if covered with glass shades or bell jars, will remain unbroken for more than 24 hours, or they may at once be blown to enormous size, may be dropped upon and will rebound from a carpet, may be cut with scissors, (wet with the solution,) and have other bubbles blown within them. Their beauty and curious effect is very remarkable.

Aqueous Lines in the Solar Spectrum.—Prof. Crooks, by a series of observations with the spectroscope, made especially during a period of very damp though clear weather, has shown that the vapor of water in the atmosphere has a very great effect in the production of absorption bands, so that in one case he found the total number visible in the spectrum increased ten-fold by this cause.

These lines abound in the red and yellow part of the spectrum, and they thus explain the blue color of the sky, (deepest in summer, when most moisture is present;) for these lines indicate an absorbtion of the red and yellow rays, leaving, therefore, the blue in excess.

A writer in the *London Chemical News* constructs bisulphide of carbon prisms in the following simple manner: A piece of sheet brass is cut into a hexagonal shape. Two opposite angles are bent at right angles to the middle part, thus forming a skeleton prism, with one solid brass face. On the open faces plates of glass are secured with paper soaked in a mixture of gelatine and glycerine, with which the interior is also smeared. A small hole is made in the brass to introduce the bisulphide.

A small electro-magnetic engine was exhibited, in which the coils of the electro-magnets were made of uncovered wire. This was presented by James Queen & Co., and operated with perfect success. The fact that coils might be thus constructed was first published about a year since by Du Moncel.

After the conclusion of the Secretary's Report, Prof. Ward gave a description of his process for marine signals.

The meeting was then, on motion, adjourned.

H. Morton, *Secretary.*

Erratum.—The name of Henry G. Morris was omitted in the list of the Committee on the Library, printed in the last minutes.

A Comparison of some of the Meteorological Phenomena of FEBRUARY 1866, *with those of* FEBRUARY, 1865, *and of the same month for* FIFTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57¼′ N.; Longitude 75° 11¼′ W. from Greenwich. By PROF. J. A. KIRKPATRICK, of the Central High School.

	February, 1866.	February, 1865.	February, for 15 years.
Thermometer—Highest—degree, .	60·00°	56·00°	70·00°
" date, .	11, 23, & 24th.	26th.	23d, '60.
Warmest day—mean,	55·00	49·17	59·30
" " date,	24th.	26th.	25th, '57.
Lowest—degree, .	7·00	3·50	—1·00
" date, .	16th.	13th.	7th'55; 8th'61.
Coldest day—mean,	15·00	12·00	4·50
" " date, .	16th.	13th.	6th, '55.
Mean daily oscillation,	13·11	11·34	13·38
" " range, .	7·42	5 97	7·22
Means at 7 A. M., .	30·87	28 45	29·39
" 2 P. M., .	39·16	36·20	38·43
" 9 P. M., .	35·68	32·44	33·60
" for the month,	35·24	32·36	33·81
Barometer—Highest—inches, .	30·547 ins.	30·322 ins.	30·671 ins.
" date, . .	17th.	21st.	4th, '63.
Greatest mean daily press	30·475	30·293	30·595
" " date, .	26th.	21st.	12th, '57.
Lowest—inches, . .	29·392	29 256	29 065
" date, . .	14th.	8th.	23d, '53.
Least mean daily press.,	29·529	29·347	29·227
" " date, .	1st.	8th.	16th, '56.
Mean daily range, .	0·245	0·205	0·222
Means at 7 A. M., .	30·032	29·872	29·924
" 2 P. M., .	29·964	29·849	29·876
" 9 P. M., .	29·999	29·875	29·909
" for the month, .	29·998	29·865	29·903
Force of Vapor—Greatest—inches,	0·424 in.	0·326 in.	0·549 in.
" date, .	24th.	26th.	16th, '57.
Least—inches, .	·048	·044	·013
" date, .	16th.	13th.	6th, '55.
Means at 7 A. M., .	·151	·124	·139
" 2 P. M., .	·170	·134	·158
" 9 P. M., .	·175	·137	·157
" for the month,	·165	·132	·151
Relative Humidity—Greatest—per ct.,	95·0 per ct.	100·0 per ct.	100·0 per ct.
" date,	8th.	23d.	often.
Least—per ct.,	30·0	35·0	20·0
" date, .	1st.	24th.	22d, '64.
Means at 7 A. M.,	79·9	75·1	78·5
" 2 P. M.,	65·2	61·4	63·2
" 9 P. M.,	76·1	71·7	75·1
" for the month	73·7	69·3	72·3
Clouds—Number of clear days,* .	13	8	8·5
" cloudy days, .	15	20	19·7
Means of sky cov'd at 7 A. M.,	45·7 per ct.	58·2 per ct.	60·4 per ct.
" " " 2 P. M.,	58·9	58·9	60·7
" " " 9 P. M.,	41·1	61·8	47·7
" " for the month	48·6	59 6	56·3
Rain and melted snow—Amount,	6·637 ins.	5·491 ins.	3·174 ins.
No. of days on which rain or snow fell,	8	10	9·9
Prevailing Winds—Times in 1000,	N70° 38′ w·265	N65° 18′ w·351	N74°23′ w·283

* Sky one-third or less covered at the hours of observation.